New York State Museum Bulletin

Entered as second-class matter November 27, 1915, at the Post Office at Albany, N. Y. under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in section 1103, act of October 3, 1917, authorized July 19, 1918

Published monthly by The University of the State of New York

Nos. 227, 228 ALBANY, N. Y. NOVEMBER-DECEMBER 1919

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

SIXTEENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTY-THIRD REPORT OF THE STATE MUSEUM, THE THIRTY-NINTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1919

	PAGE
Introduction	7
Report	8
Botany	17
Entomology	18
Zoology	26
Archeology and Ethnology	28
Staff of the Department of Science	29
Accessions to the Collections	32
Scientific Papers:	
The Tully Glacial Series. O. D. VON ENGELN	39
Paleontologic Contributions from the New York State Museum. RUDOLF RUEDEMANN	63
List of Publications	131
Index	145

ALBANY
THE UNIVERSITY OF THE STATE OF NEW YORK
1921

M1551-D20-2600

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University
With years when terms expire
Revised to November 15, 1921

1926 PLINY T. SEXTON LL.B. LL.D. *Chancellor Emeritus* Palmyra
1922 CHESTER S. LORD M.A. LL.D. *Chancellor* – – Brooklyn
1924 ADELBERT MOOT LL.D. *Vice Chancellor* – – – Buffalo
1927 ALBERT VANDER VEER M.D. M.A. Ph.D. LL.D. Albany
1925 CHARLES B. ALEXANDER M.A. LL.B. LL.D. Litt.D. – – – – – – – – – – – – – Tuxedo
1928 WALTER GUEST KELLOGG B.A. LL.D. – – – Ogdensburg
1932 JAMES BYRNE B.A. LL.B. LL.D. – – – – – New York
1929 HERBERT L. BRIDGMAN M.A. LL.D. – – – – Brooklyn
1931 THOMAS J. MANGAN M.A. – – – – – – Binghamton
1933 WILLIAM J. WALLIN M.A. – – – – – – Yonkers
1923 WILLIAM BONDY M.A. LL.B. Ph.D. – – – – New York
1930 WILLIAM P. BAKER B.L. Litt.D. – – – – – Syracuse

President of the University and Commissioner of Education
FRANK P. GRAVES Ph.D. Litt.D. L.H.D. LL.D.

Deputy Commissioner and Counsel
FRANK B. GILBERT B.A. LL.D.

Assistant Commissioner and Director of Professional Education
AUGUSTUS S. DOWNING M.A. Pd.D. L.H.D. LL.D.

Assistant Commissioner for Secondary Education
CHARLES F. WHEELOCK B.S. Pd.D. LL.D.

Assistant Commissioner for Elementary Education
GEORGE M. WILEY M.A. Pd.D. LL.D.

Director of State Library
JAMES I. WYER M.L.S. Pd.D.

Director of Science and State Museum
JOHN M. CLARKE D.Sc. LL.D.

Chiefs and Directors of Divisions

Administration, HIRAM C. CASE
Archives and History, JAMES SULLIVAN M.A. Ph.D.
Attendance, JAMES D. SULLIVAN
Examinations and Inspections, AVERY W. SKINNER B.A.
Law, FRANK B. GILBERT B.A. LL.D., *Counsel*
Library Extension, WILLIAM R. WATSON B.S.
Library School, EDNA M. SANDERSON B.A. B.L.S.
School Buildings and Grounds, FRANK H. WOOD M.A.
School Libraries, SHERMAN WILLIAMS Pd.D.
Visual Instruction, ALFRED W. ABRAMS Ph.B.
Vocational and Extension Education, LEWIS A. WILSON

COMMONWEALTH MYCOLOGICAL INSTITUTE
1967

The University of the State of New York Science Department, August 30, 1920

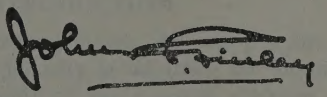
Dr John H. Finley
President of the University

SIR: I beg to transmit herewith my annual report as Director of this department and to request its publication as a bulletin of the State Museum.

Very respectfully yours

JOHN M. CLARKE
Director

Approved for publication



President of the University

New York State Museum Bulletin

Entered as second-class matter November 27, 1915, at the Post Office at Albany, N. Y., under the act of August 24, 1912. Acceptance for mailing at special rate of postage provided for in section 1103, act of October 3, 1917, authorized July 19, 1918

Published monthly by The University of the State of New York

Nos. 227, 228 ALBANY, N. Y. November-December 1919

The University of the State of New York

New York State Museum

JOHN M. CLARKE, Director

SIXTEENTH REPORT OF THE DIRECTOR OF THE STATE MUSEUM AND SCIENCE DEPARTMENT

INCLUDING THE SEVENTY-THIRD REPORT OF THE STATE MUSEUM, THE THIRTY NINTH REPORT OF THE STATE GEOLOGIST AND THE REPORT OF THE STATE PALEONTOLOGIST FOR 1919

INTRODUCTION

The work of this Department during the year past has suffered grave handicap from the difficulty of adjusting the income of the organization to the demands of the research divisions and the proper maintenance of the Museum. Inadequacy of compensation to the scientific employees has resulted in the loss of valuable men who have served loyally and sacrificed bravely but have at last reached the limit of resistance to the temptations of the industrial world. As long as the attachés of the scientific staff are without assurance of a decent living, are forced into situations where they must sacrifice even their Liberty Bonds to make ends meet, there must result not only a loss of the best service which can not be made good, but also a serious impairment of the spirit in which the work is done; a lessening of devotion and enthusiasm and a weakening of the bond of respect which the employee has toward the supreme employer. This relation between the State and its servants is, for this Department as doubtless for others, of the most serious concern for the efficiency of the organization.

REPORT

Geology. In pursuance of the plan for the completion of the geological map of the State on the scale of 5 miles to 1 inch, areal surveys have proceeded over several quadrangles.

In the Adirondacks region the Russell quadrangle has been covered by Dr William J. Miller and a report rendered thereon. The survey of the Lake Bonaparte quadrangle has been completed by Dr A. F. Buddington. The work upon the survey of the Mount Marcy and Ausable quadrangles has been concluded by Prof. James F. Kemp, aided by Harold L. Alling. The survey and mapping of the West Point quadrangle undertaken especially as a means of facilitating instruction in geology at the United States Military Academy has been carried through by Dr Charles P. Berkey, superintending the field work of Marion Rice. The report on the geology of the Gouverneur quadrangle by Prof. H. P. Cushing is completed.

All the reports listed above are in condition for publication.

Other geological activities have been a continuation of the examination and surveys of the postglacial deposits and drainage by Dr James H. Stoller in the Saratoga region, Harold L. Alling in Essex county and John H. Cook in Albany county, while Prof. H. L. Fairchild has been engaged with the special problem of the evolution of the upper Susquehanna valley, a work which it is hoped to extend to the entire course of the Susquehanna with the aid of the director of the Geological Survey of Pennsylvania.

Researches upon problems relating to the mineral industry which have engaged attention have been connected with the origin and composition of the salt deposits of the State, a work which has entailed a large amount of analytical examination for the purpose of acquiring more exact information regarding the potash and other minor contents of these deposits. Much of this work has been executed by Mr Alling under the supervision of David H. Newland, Assistant State Geologist. A restudy has also been made of the iron ores of Orange and Putnam counties by R. J. Colony of Columbia University.

Paleontology. In the category of special problems, Mr Hartnagel has prosecuted further study of the Clinton formation and fauna in central and western New York, which has been productive of interesting results both in paleontology and stratigraphy.

Doctor Ruedemann has advanced his investigations of the Lorraine fauna of the Ordovician and has now completed a revision of the formation and fauna in which are substantial additions to the

The road bed 3 miles north of Otisco, crossing an outcrop of Hamilton (Middle Devonian) shale. Every pebble shown in the picture is a fossil coral. Photograph by Dr W. J. Sinclair.

previous knowledge of the subject. It is hoped that it may be possible to publish this notable report in the near future.

In previous reports reference has been made to progress on the monograph of the Devonian crinoids. This extensive undertaking which has been carried forward by W. Goldring, has been completed. Its conclusion puts a period to an undertaking of long standing.

My last report contained the results of the examination of the Bonaventure cherts made by Dr Rufus M. Bagg and the results have been of such interest that Doctor Bagg has been asked to prosecute an investigation of the Devonian cherts of the Onondaga limestone with the purpose of determining the microscopic life contained therein.

Paleobotany. In all the history of paleontological investigation and collection in the State, fossil plants have been brought together quite incidentally to other investigations. Seldom has any special effort been made to search them out or to make a careful study of them. Notwithstanding, the Museum has by this desultory procedure come into possession of a very extensive and variant collection of the terrestrial plants of the Devonian period, a collection which has been authoritatively characterized as one of the largest assemblages known. Paleobotany is a phase of paleontology which has not received its share of attention in America and an understanding of the first terrestrial floras of the world has been restricted to a very small circle of students. This is a condition which has prevented the entry of this knowledge into the understanding of intelligent men, all the more regrettable as it is the branch of knowledge which has had to do with the beginnings of the whole world of plant life. The paucity of this knowledge and the intelligent requirement for more of it have led the Geology Division of the National Research Council to establish a committee on paleobotany in accordance with the purposes of which, as suggested above, provision has been made for a systematic pursuit of this field in this State. Several collectors are now in the field in search of this material and their efforts have thus far been attended with excellent results. A promising outcome of this work is indicated by the following account of the rediscovery of the fossil "fern" trees of Gilboa in the upper Schoharie valley.

The fossil trees of Schoharie county. A great autumn freshet in the upper valley of the Schoharie creek in 1869 tore out bridges, culverts and roadbeds around the little village of Gilboa and exposed in the bedrock of the hills a series of standing stumps of

trees. These stumps stood all on the same level in the rocks and their rootlets ran down into the original mud in which they had grown, now turned into a dark or greenish shale. All had been cut off by some ancient flood at about 3 feet above the base; some were large and some smaller, the largest having a diameter in the shaft of 2 feet or more with broad expanding root-base like a flattened turnip. Thus was brought to light the standing remains of the most ancient forest growth known in the geological records in any part of the world. Ten of these tree stumps were taken out from their ancient forest, all at the same level in the rocks, and most of them were brought to the State Museum, where they have long constituted one of the remarkable exhibits of the vanished flora of the State.

The effort made this year to relocate this primeval forest of the Devonian Period or to find some additional evidence of its extent has proved successful. The old locality is deeply covered and the rocks of that level which carried these trees do not come to the surface again in the vicinity. But the work has been attended with unexpected results in finding the stumps of other trees of the same sort at a level 60 feet higher in the rock beds, giving evidence that the forest growth had reappeared in the same region at a later stage in Devonian history.

The rediscovery of these primitive "ferns" is of very great interest from a scientific point of view. These trees are most nearly comparable to the tree ferns of existing tropical forests but no botanist would be content with this comparison, as they have a frutification quite unlike the spore-cases of the ferns, and the leaves were apparently narrow and straplike, branching simply and rarely and terminating in twin fruit cases. If the diameter of the trunks is carried upward in a tapering slope these trees must have reached a very considerable height of 20 to 30 feet, but it is possible that the trunks broke up not so far above their base into a shrubby or bushy cap. Their real nature is still a problem for the student of fossil plants. This will be disclosed in time but whatever the nature of this primitive forest growth may prove to be, they certainly afford an index to the geography of the western Catskills and the Schoharie valley during the late Devonian Period to which they belong. We have said that the tree stumps were found in places where they grew, that the shale under them are the muds in which they were rooted and that they are preserved at at least two levels in the rocks, one 60 feet above the other. Not far under the lowest forest the rocks carry true marine fossils. Tangled in the roots of the lower trees were found the remains of some brackish water animals. These facts of

Upper forest bed at Gilboa with tree trunks in place

Enlargement of one of the tree trunks in place

themselves show that the sea which covered this region slowly withdrew and the trees crept down from land to the water's edge, or grew over the delta plain of the fresh-water streams flowing in from the old land at the east. Then for a long time the first forest must have been flooded by the waters, probably by the rising of the sea which deposited the 60 feet of overlying rocks, until another retreat of the water again brought the forest down to the shore. There was an oscillation of the coast line, the sea rising and falling and the trees approaching, receding and approaching again toward the edge of the water. The story of the earth's primitive forest when fully written promises to be an interesting one, and it is hoped to reproduce, in part at least, in the State Museum, this picture out of the dim past.

It may be added to the foregoing " story " that these stumps when first found and recorded in the 18th report of the Museum, were studied by Sir William Dawson, then principal of McGill College and in his day the leading authority on the plants of the Devonian, and were regarded by him as probably " tree ferns," Psilophyton textilis, but present evidence indicates that they were also related to the cycad palms and probably are associated to the cycadofilices which were allies to both these groups. The location of the new series of stumps has been due to Herbert S. Woodward, who has had the assistance of Messrs Ruedemann and Hartnagel in the careful extraction of the remains and in the important discovery of the fruit cases.

Archeology. Excavations on Boughton Hill. Late in the summer of 1919 some field work was done on the historic Boughton Hill site in Ontario county. This site, which has been the scene of excavations and speculation on the part of antiquarians for more than a century, covers portions of the Green, Moore and McMahon farms in the town of Victor. The heart of the village seems to have been located on what is now a narrow strip 300 feet wide on the Moore farm. This strip was leased by the Museum and operations commenced on September 10th. It required but a few days of excavation to demonstrate that the site had been dug over for a period of many years and that but little remained for the systematic excavator to find. By persistent effort and by careful work twenty-five graves were discovered during a period of 30 days. The success of this search is due to the interest and conscientious labors of Everett R. Burmaster, who during a period of 15 years has acted as a field helper or as an advisor. The digging at Boughton Hill was difficult owing to the condition of the soil, which is a compact gravel-

mixed clay. The difficulty was increased by the unsystematic excavations of amateurs whose filled-up prospects constituted false leads in many instances.

The Moore farm is divided into two general sections, the agricultural plot on the top of the hill, and the pasture plot on the west slope. The portion excavated in the autumn of 1919 was the brow of the hill in the pasture plot. Here on two lobate ridges running out into the brook valley, were found the burials. The specimens recovered include one bone comb, four clay pipes, a woven pouch, two wooden spoons, several strings of wampum beads and shell runtees. European material included glass beads, brass kettles, brass arrow points, gun locks and barrels, knives, chisels and punches. Of considerable interest are the specimens of dried foods, further preserved from decay in the ground by impregnation with copper salts derived from oxidation of brass kettles. These foods include apples, grapes, squash rind and seeds, pressed berries, corn bread and corn. Some tobacco leaf and "fine cut" Virginia is also among the preserved vegetable substances. Through substances such as these it is possible to determine some of the foods used by the Indians who lived at Boughton Hill.

The site is that known as Gandagora by the French. To the Indians it was Ga-on-sa-gaa-ah. This village was one of the great towns of the Seneca and was known to the colonists as early as 1637. During the conflict of the Iroquois with the French of Canada the village was attacked by Governor Denonville. With him were 1600 French soldiers, 800 of whom were trained men from France; the rest were hastily drilled habitants. To supplement this force there were some 1400 Indian allies, mostly Hurons and Ottawas. The Seneca occupants made several feeble efforts to defend their homes, but they were outnumbered ten to one. Fleeing before the superior invading force they abandoned and burned the village and fled to Gayaanduk, a fortified hill a half league to the west. This was almost immediately abandoned and burned, leaving the French and Indian invaders the task of destroying the corn fields and public storehouses. The French destroyed four principal villages of the Seneca and burned several small settlements, together with their corn fields and garden plots. A few Seneca Indians were killed but the Ottawa allies of the French accused Denonville of killing more horses and pigs than Seneca enemies. "You have destroyed the nest," said one Indian ally, "but you have left the hornets with their stings."

Antler spoon from a grave at Boughton Hill.
Excavated 1920.

Types of antler combs found at Boughton Hill, 1920

Antler combs found in graves at Boughton Hill, 1919–20

Antler combs found in graves at Boughton Hill, 1920

It was hoped that this important site might yield a large number of interesting remains that would shed light on the Denonville period of the Seneca. Our success during 1919 was sufficient to warrant an additional examination during May 1920. Operations were started on May 15th, the entire tract of land on the Moore farm being post holed. For the first two weeks little was found, but as the work started on the east side of the hill at a point that must have been the old stockade line, burials were found in numbers. Nearly two each day were unearthed. In all in the thirty-three graves there were found about fifty skeletons. The burials at this spot differed considerably from those on the west side, in that there were many disassociated remains. This may be due to several causes; first, the remains may be those of the slain after the battle; second, they may be the remnants of the house-burials; third, they may be the remains of those "buried" in trees and later taken down and thrown in burial pits.

In the east burial site European artifacts were numerous, the usual iron axes, copper and brass kettles and iron knives occurring in about the same proportion as on the west side. The articles of native manufacture found here include one antler spoon with a forklike end, four complete bone combs and three combs with broken teeth. A number of triangular arrow points were recovered, these being exceedingly rare as surface finds since the inhabitants had used guns for a generation before the destruction of their village. Beads of many kinds were found. Where possible they were restrung bead for bead as taken from the burial. In this manner we have restored several of these necklaces to their original condition. Of exceptional interest are the two pottery vessels found in graves. These were in a broken condition but it is hoped that they may be restored. Very few pottery fragments have been found on Boughton Hill and so far as we know none has been found in a complete condition, or even sets of restorable fragments. The type of pottery is a modified serrated or scalloped edge, of the Seneca or Neutral style of 1650. One pot has four perforated knobs that were evidently handles.

The interesting history of Boughton Hill and the character of the recoveries will make our two expeditions the subject of a larger and more complete report. It should be noted now, however, that the site was secured through lease by favor of Mrs F. F. Thompson of Canandaigua, to whom the Museum is indebted for many gifts and favors. The field experts this year were George E. Stevens and David B. Cook, both of Albany.

The Cornplanter Medal. The 1920 Cornplanter Medal was bestowed upon Mrs Mary Clark Thompson of Canandaigua in recognition of her numerous services in connection with movements related to archeology, ethnology and history. The medal was received for Mrs Thompson by the Director of the State Museum, who made an appropriate address.

The ceremonies of presentation are held under the auspices of the Cayuga County Historical Society of Auburn. The medal is given for notable services to the science of anthropology, to philanthropists who have given great benefits to the Iroquois, the historians, writers and artists, all of whom must have contributed to the knowledge or welfare of the Iroquois. Up to the present time three other persons associated with the State Museum have received the medal, William M. Beauchamp, Arthur C. Parker, Alvin H. Dewey.

The New York State Archeological Association. This organization, started four years ago, is flourishing and growing in numbers and enthusiasm. Its publications are popular and have had a considerable circulation. At present there are three organized chapters, one at Cooperstown, one at Rochester and one at Schenectady. The Rochester chapter has more than 250 members and gives a regular course of lectures, generally ten in number each season. Its annual banquets provide the means for a gathering of archeologists from all parts of the State. At the February 1920 meeting, Mr Langdon Gibson, president of the Mohawk Valley chapter, Schenectady, gave the principal address on "Tramping the Arctics with the Eskimo." A new chapter is under way in Syracuse and only awaits installation. It has been suggested that this chapter be named after William M. Beauchamp LL. D., the dean of archeologists in this State.

Activities of the New York State Indian Commission. At the beginning of this fiscal year the State Legislature created the New York State Indian Commission to be composed of members of the Legislature and certain representatives of state departments. The Governor selected the Archeologist of the Museum as the representative of the Education Department and at the organization meeting of the commission the Archeologist was elected secretary. In this way there has been no uncertain recognition of the ability of the State Museum to supply information relative to the Indian inhabitants of the State.

The commission has as its duty the study of the status of the New York tribal Indians and a subsequent conference with the committees of Congress relative to that statute. There is an apparent con-

flict of jurisdiction between the state and federal governments respecting Indian affairs. Beyond this the Indian tribes claim a certain independence and have asserted the right to regulate their own internal affairs. Certainly the Empire State can well afford to make a thorough study of this situation and provide the needed relief to these nations once so powerful as to be courted by the foreign powers that sought to colonize America.

The Indians chiefly affected by this commission are the Onondaga nation, near Syracuse; the Oneida tribe near Oneida; the St Regis Mohawks in Franklin county; the Tonawanda Seneca Band in Genesee and Erie counties, near Akron; the Tuscarora tribe, near Lewiston, Niagara county; the Seneca Nation on two reservations, one near Gowanda and one near Salamanca.

Each tribe has a somewhat different status but all are regarded as wards of the federal government and all fall under the provisions of the Pickering treaty of 1794-95. This treaty pledges the Indians immunity from disturbance and interference in the possession of their lands. While the Indians are regarded as "wards" we have not been told when they became wards or how, for when the treaties were drawn these Indians were regarded as competent contracting parties. Somewhat later they were denominated wards. If they are wards of the federal government the question arises as to what right the State has to legislate for them and how it can force the Indians on their several reservations to obey state law. The government has been disposed to let the State care for the Indians in the matter of schools, highways, enforcing the sanitary code, and in cases of the poor and indigent. There is now some question as to the right of the State to do this, though the moral propriety of the fact is not impeached. The Indian Commission is charged with the task of bringing about a well-understood status and in eliminating the causes of dissatisfaction and the barriers to progress. If the Museum through its department of archeology can be of assistance in clearing up this vexatious problem that has troubled the administration of Indian affairs in this State for so many years it will be felt that a practical good has been accomplished.

The members of this Commission are Assemblyman E. A. Everett, chairman; Senator Loring F. Black, vice chairman; Speaker Thaddeus C. Sweet, J. Henry Walters, De Hart H. Ames, Attorney General Charles D. Newton, Charles D. Donahue, Peter McArdle, Dr Robert W. Hill, Dr Matthias Nicholl jr, Chief David R. Hill, Arthur C. Parker, secretary.

New York Indian Welfare Society. During the month of May a general call was issued to the Indians of this State and their friends calling them into a general conference for the purpose of discussing their present and future needs. The meeting was held May 11th in the Historical Society Building in Syracuse and on the 12th at the Onondaga Council House. For the first time in many years Indians of all classes and schools of thought met in joint conference. The temporary chairman was Jesse Lyon, the courier of the Six Nations. Mr Lyon is a stalwart exponent of the old régime and is bitterly opposed to citizenship, preferring the citizenship of his tribe to that of the United States. After a vigorous session in which each division explained its beliefs, an election was held. The officers selected are: A. C. Parker, president; Dr Louis Bruce, a St Regis Mohawk, treasurer; David Hill, an Onondaga, secretary. The vice presidents are: George Thomas, Onondaga; Nicodemus Billy, Tonawanda; Alexander Burning, Oneida; Delos Kettle, Seneca. The councilors are: Jesse Lyon, Onondaga; Moses White, St Regis; Howard Gansworth, Tuscarora; Rolling Thunders, St Regis. There is also an advisory board composed of two sections; the section of the last conference and the section of the future conference. Dr William M. Beauchamp is chairman of the Syracuse section and Alvin H. Dewey, chairman of the Rochester section. The Rochester meeting will be held November 11, 1920 under the auspices of Morgan chapter of the New York State Archeological Association. This organization was conceived by Dr Earl E. Bates of Syracuse, who is the honorary president.

At the Syracuse meeting in May there were present representatives of the State Indian Commission, including Chairman E. A. Everett, David R. Hill and Dr Robert W. Hill. The Friends Indian School of Tunesassa was represented by William A. Rhoads, superintendent, and Henry Leeds, missionary.

Wild Flowers. The "Wild Flowers of New York" has been completed and published. This quarto work in two volumes has engaged the attention of the State Botanist for five years and has been progressed and brought to conclusion in spite of great difficulties growing out of the war and its consequences. The beauty of the execution of this work is greatly to the credit of all who have had a part in its making and it is confidently believed that it will render an excellent service in disseminating a knowledge of the native flora of the State.

Living Mollusca. For many years as time has permitted, there has been in preparation an illustrated report on the Mollusca of the

Delos Big Kettle (Sai-no-wa), a Seneca chief, and the Rev. William M. Beauchamp (aged 92), for many years author of and contributor to State Museum bulletins on Indian subjects.

State by Dr Henry A. Pilsbry of the Philadelphia Academy of Natural Sciences, the recognized leading authority in this field. This work is now practically complete and it will be offered for publication in the hope of reviving among our people the interest in the "belle science" which was so keenly alive a half century ago.

BOTANY

The work of the State Botanist's office during the year ending July 1, 1920, has been largely a continuation of lines of investigation and routine previously reported upon.

Field investigations. During the latter part of the season of 1919 there was carried on a continuation of botanical field work in the lake region of central New York, particularly about Oneida lake, and the region immediately to the east of that body of water. Several species of plants and fungi previously unknown to that region were found and added to the state herbarium. Particular attention was given to those fungi known as plant rusts.

A few days during May 1920 were also spent in the same region, resulting in additional knowledge regarding the early spring vegetation of that region.

In late June, four days were spent at Lake Bonaparte, northern Lewis county, supplementing field work during early June of 1919, at the same place. The results of these field investigations will appear in the reports of the State Botanist for 1919 and 1920.

Ferns and flowering plants of New York State. A complete list of the ferns and flowering plants of this State which has been in course of preparation for some time has nearly reached completion. This list gives the scientific and popular name of every species known to occur within the boundaries of the State, the comparative abundance of each one, and in case of those species which are rare, local or very uncommon, the previously published notices of them are cited, and definite reference to authentically determined specimens in the leading herbaria are added. Similar lists have been published upon the flora of New Jersey, Connecticut and other states and have fulfilled a long felt demand upon the part of those interested in the vegetation of these states, both from a popular and from a scientific point of view.

Determinations. During the six months ending July 1, 1920, the State Botanist's office has been called upon to determine 165 specimens of plants (including fungi and ferns). These determinations were made for 47 persons, only six of which were from outside the State.

State herbarium. Continued curatorial work on the collections has resulted in bringing the large assemblage of fungi, mosses, lichens, ferns and flowering plants into an improved systematic arrangement.

In addition to assembling the current collections for incorporation into the herbarium, a large amount of unmounted material has been brought together and is in process of being mounted by competent temporary assistance, beginning June 15, 1920.

ENTOMOLOGY

The Entomologist reports that the season of 1919 was made noteworthy in entomological annals by the discovery in late January of the European corn borer at Scotia, Schenectady county. The infestation was found subsequently to include portions of Albany, Schenectady, Schoharie, Montgomery, Fulton, Saratoga and Rensselaer counties, and to extend from a little east of Troy westward to Fort Hunter, north nearly to Saratoga and south to Esperance. The presence of the pest on the Mohawk flats made the problem more serious because there was constant danger of high water with the accompanying drifting of corn stalks, some presumably containing living caterpillars, down the river.

The situation was carefully studied in early February and after a series of conferences with state and federal authorities, it was decided to make an attempt to clean up the infestation and prevent the further spread of the pest. The entomologists of the State were unanimous in adopting a progressive policy and as an outcome of their representations the Legislature passed an emergency act appropriating $75,000 to the State Department of Farms and Markets to be used for corn borer control. Although the time for doing effective work was very limited, and conditions in early spring decidedly unfavorable for effective operations, the undertaking resulted in a very satisfactory clean-up of the known infested territory, which at that time approximated 300 square miles. There was then no good ground for believing there would be but one generation of the insect in New York State and that consequently local injury would be comparatively slight because there is only a small variation in climatic conditions between the infested section about Boston, Mass., where two broods are the rule, and the territory where this insect was found in eastern New York. This peculiar restriction could not be demonstrated until mid-September conditions indicated that the borers had ceased activities for the season.

Another infestation was discovered at North Collins, Erie county, in early September 1919, and as a result of scouting by both federal and state men the infested area in that section has been found to approximate 400 square miles and to include portions of Cattaraugus, Chautauqua and Erie counties.

The situation was of more than usual interest since in early spring it was impossible to get more than a tentative identification because Pyraustid larvae, a group to which the European corn borer belongs, are so similar that at the time no unquestioned recognition characters were known. The situation was further complicated by the fact that a very similar borer occurs rather commonly in smartweed and while this latter is of no economic importance, it occasionally bores in corn stalks and it was therefore necessary to distinguish between this harmless native species and the much more dangerous European introduction, if state money was not to be wasted in cleaning up areas outside the infested territory. The Entomologist addressed himself to the early solution of this problem and after securing series of specimens from different sections of New York State and from other parts of the country, worked out differentiating characters which have been largely sustained by later investigations.

Conditions were such in the spring of 1919 that it was very desirable to ascertain at the earliest possible moment the distribution of the European corn borer in the State, consequently bulletins, posters and circulars were widely distributed. The Entomologist prepared a brief circular letter which was sent very generally to schools of the State, Cornell University Extension Bulletin 31, of which an edition of 40,000 was printed, and the Education Department's Bulletin to the Schools of June 1st, the last illustrated by four admirably executed colored plates. Numerous press notices were also sent out. The Department of Farms and Markets published Circular No. 182 and issued a number of quarantine orders. The result of these publicity and regulatory measures was an extraordinary interest in all manner of corn insects and as an indirect outcome valuable information was secured concerning a number of comparatively unimportant pests, notably the lined corn borer and grass webworms.

The European corn borer is of such general importance and its habits in New York State so different from those in Massachusetts that application was made to the Legislature for a special appropriation for the investigation of the status of this insect and $5000 was appropriated. This money is being used in a careful field study of the pest to ascertain the rapidity of spread, the amount of injury

and the possibilities of control or repressive measures. The work has been placed in charge of D. B. Young, who was temporarily detailed from the Entomologist's office. Hall B. Carpenter of Somerville, Mass., was also engaged as a special assistant for this work. Data in regard to a large number of fields have already been secured and much material collected which will be duly classified at the close of the active season. Results so far obtained clearly indicate a considerable difference in habits in New York State as compared with the infested areas of Massachusetts. These variations are of much practical importance because of their bearing upon quarantine restrictions or other methods designed to prevent further spread. A detailed report upon this work can not be completed for some months.

Early in July 1919, the Entomologist was appointed collaborator of the Bureau of Entomology, United States Department of Agriculture, and specifically authorized to investigate corn borer control in the states of New York and Massachusetts. He was also appointed chairman of a subcommittee on the European corn borer, subsequently changed to a subcommittee on insect control, of the committee on policy of the American Association of Economic Entomologists and a member of a special committee appointed at the Albany-Boston conference on the European corn borer. He has in these various activities been able to exercise a marked influence upon both state and national phases of the situation. He has felt compelled to do this because the insect is one of national importance and measures adopted in one commonwealth must be contingent to a greater or less extent on those enforced in other states or pressed to a successful conclusion by the representatives of the federal Bureau of Entomology. A detailed account of the investigations and activities in relation to this recently introduced pest may be found in the Entomologist's report.

Other corn insects. The great interest in the European corn borer caused most careful and repeated examinations of corn throughout the State and one outcome was the finding and reporting of a number of injurious species. The lined corn borer, hitherto supposed to be rare in New York State, was found to be rather widely distributed and frequently injuring a considerable proportion of the corn on recently turned sod.

The well-known stalk borer, a generally recognized pest in a variety of thick-stemmed plants, caused numerous complaints, though in most cases the injury was by the corn ear worm. This last was in not a few cases thought to be the European corn borer.

Several less-known corn insects were also brought to the attention of the Entomologist.

The material received during the past season has made possible a more accurate appraisal of the economic status of these different forms and in order to facilitate their recognition a popular key giving the more conspicuous characters was prepared and generally distributed as a special folder. Additional details regarding the work of the different species may be found in the Entomologist's report.

Small grain pests. Studies of the wheat midge, Thecodiplosis mosellana Gehin., begun in 1919, were continued the past season and much additional information secured concerning the economic status of the pest. It was found to be generally present in the rye fields of the eastern part of the State and in wheat fields in the western area. It was particularly abundant in portions of Genesee, Monroe, Niagara and Wayne counties, the indicated reduction ranging from 17 to 27 per cent with very little crop injury from wheat scab or loose smut. The data show close correlation between the abundance of maggots and the number of shrunken or blasted grains of wheat and rye. The evidence at hand indicates a presumably much greater loss from wheat midge infestation than has hitherto been suspected. A detailed discussion of the data is given in the Entomologist's report. The collation of similar data for 1920 is in progress.

The Hessian fly, Phytophaga destructor Say, is one of the most destructive and best known wheat pests. Through the courtesy of Prof. C. R. Crosby of Cornell University and W. R. McConnell of the United States Bureau of Entomology, the Entomologist has been able to include in his report summarized data concerning the abundance of this insect in the State for the years 1917 to 1919 inclusive. It will be seen by reference to the discussion in the body of the report that there has been an increase in the average infestation from 2.6 per cent in 1918 to 7.44 per cent in 1919, the most marked increases occurring in Genesee, Monroe and Wayne counties. These data are of value since they indicate tendencies in different parts of the State and can be used advantageously in designating areas where stricter adherence to precautionary measures is advisable.

Wheat joint worms, Isosoma tritici Fitch and I. vaginicolum Doane, occur throughout the State and as in the case of the Hessian fly, data have been included concerning the abundance of these two insects for the years 1918 and 1919. Reference

to the summary in the report of the Entomologist shows a decrease the past season in the abundance of both joint worms, this being particularly marked in Genesee and Schuyler counties with a tendency in the opposite direction in the case of Ontario and Orleans counties.

Observations upon the army worm, Heliophila unipuncta Haw., show that the partly grown caterpillars survived the very severe winter of 1918-19 in Saratoga county, they being repeatedly found in partly rotted corn stalks, and in smaller numbers in the spring of 1920. These are new records for this section of the county and have an important bearing upon army worm outbreaks.

A distinctly unusual feature was the submission of leather jackets or maggots of a crane fly, Pedecia albivitta Walk., accompanied by the statement that they occurred in large numbers in Schuyler county in an oat field and were presumably causing some injury.

Other field crops. The ordinary crop pests attracted comparatively little attention, though in early spring there was considerable complaint of an unusual abundance of asparagus beetles, Crioceris asparagi Linn. These insects were specially troublesome upon commercial beds, not only because of their feeding upon the shoots, but on account of the numerous black eggs which necessitated very careful washing before the asparagus was taken to market.

There was a distinctly unusual outbreak of the green clover worm, Plathupena scabra Fab., upon beans, the greenish white-striped caterpillars feeding generally upon the leaves of both common and lima beans and causing serious and somewhat general injury in various parts of the State.

Codling moth. Field studies of the codling moth have been continued in cooperation with the bureau of horticulture of the State Department of Farms and Markets. Special attention was given to securing exact records of evening temperatures as well as the maxima and minima. The accuracy of this work was materially increased by the cooperation of the United States Weather Bureau in loaning thermographs and supervising the setting up of the instruments. The intimate relations existing between evening temperatures and codling moth oviposition are graphically represented in a chart prepared by L. F. Strickland, who was also responsible for the observations upon egg deposition in various orchards. The demonstration of this relationship is a material step in solving the vexatious problem of codling moth control in the western part of the State.

The series of experiments to determine the relative efficiency of the several sprays for control of the codling moth in the western part of the State have been continued. The most marked results, as were to be expected, were obtained from the first or calyx application and while the reduction in wormy apples was decidedly less in the case of the second and third treatments, there was no question but that these additional sprays are amply justified by other considerations.

Tests of the value of nicotine in the spray applied about three weeks after blooming, indicate little benefit in the destruction of adult codling moths or recently deposited eggs and so far as this insect is concerned, the inclusion of this costly insecticide in the second application can not be advised though it is undoubtedly very beneficial when aphids are numerous. The data in relation to this insect secured the past season are discussed in some detail in the body of the report.

Shade tree insects. The past season was marked by the discovery of another pest in the United States upon which has been tentatively bestowed the common name of elm ribbed cocoon-maker. It is with very little question the European Bucculatrix ulmella Zell. It has been reported as seriously injuring European elms in the Rochester parks.

A recently introduced willow leaf beetle, Plagiodera versicolora Laich., was brought to notice the past season on account of the serious injury to weeping willow foliage in New York City. It is also known as a pest of poplar and may possibly be of some service in checking the indiscriminate planting of this somewhat undesirable shade tree.

The elm leaf beetle, Galerucella luteola Mull., was somewhat injurious here and there in the State, particularly outside of areas where it was very destructive 10 to 15 years earlier. This is probably due in part to better control in localities where the insect has caused the most damage and partly to the somewhat unfavorable climatic conditions of recent years.

The bronze birch borer, Agrilus anxius Gory, continues its nefarious work and here and there throughout the State many magnificent birches are succumbing to the work of this borer. It is only a question of time before all the cut-leaved birches will succumb unless they are systematically protected.

A compilation of the office records of the last twenty years indicate a probable biennial life cycle for the large, strikingly colored Say's blister beetle, Pomphopoea sayi Lec. This insect

is numerous approximately every other year when it attracts attention on account of its feeding in swarms upon the blossoms of various trees, particularly honey locust.

Forest insects. The destructive work in recent years of the hickory bark beetle, Eccoptogaster quadrispinosa Say, has resulted in bringing to attention a number of insects of secondary importance. Notes upon these latter have been compiled and are placed on record in a summarized form in the Entomologist's report.

There was an outbreak of the antlered maple caterpillar, Heterocampa guttivitta Walk., in Chautauqua county, accompanied by defoliation of sugar bush in areas where the insects were most abundant.

The interesting maple leaf cutter, Paraclemensia acorifoliella Clem., again attracted notice on account of its unusual abundance in the vicinity of Lake George.

Lectures. The Entomologist has delivered a number of lectures or participated in discussions on insects, mostly economic species, before various agricultural and horticultural gatherings, some of these being in cooperation with farmers institutes or county farm bureau agents; a considerable proportion, owing to the conditions prevailing during the past year, have related to the European corn borer and its control. Some of the more important were before a subcommittee of the United States Senate at Washington, a special meeting of the Council of Farms and Markets at Ithaca, a special conference of state commissioners of agriculture and official entomologists at Albany, the annual meetings of state commissioners of agriculture at Chicago and the American Association of Economic Entomologists at St Louis.

Gall midges. The 33d report of this office, issued during the period covered by this report, contains part 6 of the study of gall midges, a portion devoted to many very interesting and highly complex members of the tribe Itonididinariae, one of the common representatives being the pear midge. The Key to the Sub-families, Tribes and Genera of the Itonididae or Gall Midges of the World, which appeared in the Philippine Journal of Science during the present year, is the most comprehensive paper of this character which has yet appeared.

Gall insects. The "Key to American Insect Galls" was published during the past year. It is the only comprehensive tabulation of these interesting deformities in America and since it deals primarily with the more obvious swellings or plant malformations

rather than with the minute and highly complex gall makers themselves, it will greatly facilitate the study of the interrelations between plants and insects. Owing to the great demand for this bulletin, the edition was rapidly exhausted.

Publications. A number of brief popular accounts relating to the more important insect pests have been prepared as heretofore and widely circulated through the county farm bureaus, local papers and the schools.

The Report for 1917 did not appear until the current year and it and the Key to American Insect Galls, mentioned above, are the two Museum bulletins on entomology which were issued during the year. The publications relating to the European corn borer and to gall midges have been mentioned above.

Collections. Very desirable additions to the state entomological collections have been made during the year, some of the best material being reared in connection with studies of insect outbreaks or as a result of requests for information concerning previously unknown forms. Special attention has been paid to the acquisition and preservation of immature stages, since these are very difficult to secure. This is particularly true of a number of borers similar to the European corn borer found in the stems of various plants. The special work upon the European corn borer is resulting in numerous additions to the state collections.

Henry Dietrich, now of Berkeley, Cal., most generously donated to the Museum 551 specimens of Coleoptera, representing 160 species, 55 of these being new to the state collections.

D. B. Young, assistant entomologist, donated from his personal collections of earlier years, a large series of Coleoptera, consisting of 648 specimens belonging to 369 species previously unrepresented in the state collections. This large addition to the collections has necessitated the rearranging of most of the Coleoptera and in addition it involved the study and identification of numerous obscure species. This work has been prosecuted in addition to numerous identifications for correspondents and other routine duties.

Miss Hartman's time has been very fully occupied in addition to the usual duties of the assistant, by the many translations of technical literature needed in systematic work, the making of numerous excellent microscopic preparations of small insects and the arrangement and care of the pressed specimens of insect work and the extensive accumulations of alcoholic material.

The many additional calls upon the staff incident to the work upon the European corn borer has greatly restricted the amount of time

which could be given to the identification and arrangement of collections, though some progress has been made along these lines.

The special work upon European corn borer authorized by the last Legislature necessitated the temporary transfer of Mr Young to take charge of the work and the appointment of W. H. Hoffman to fill the temporary vacancy. Hall B. Carpenter has been appointed special assistant in corn borer work.

It is impossible, as pointed out in the previous report, to build up the state collections in a satisfactory manner without more funds and assistance, since work of this character is very exacting and time-consuming.

Horticultural inspection. The nursery inspection work of the bureau of plant industry, State Department of Farms and Markets, has resulted as in former years in a number of specimens representing various stages of insect development, some in very poor condition, being submitted to this office for identification.

The need of accurately identifying borers in weeds and corn found in connection with European corn borer operations of last summer has resulted in the Entomologist giving much time to the study of boring caterpillars for the purpose of distinguishing between the destructive and comparatively innocuous forms. This was very important since the boundaries of the infested territory were necessarily determined by the identifications of all such material.

General. The work of the office has been materially aided as in past years by the identification of a number of species through the courtesy of Dr L. O. Howard, chief of the Bureau of Entomology, United States Department of Agriculture, and his associates. There has been very effective and close cooperation with the State Department of Farms and Markets, particularly the bureau of plant industry, the county farm bureau, the State Experiment Station and various public welfare organizations. A number of correspondents have donated material and rendered valuable service by transmitting local data respecting various insects and assisting in other ways. It is a pleasure to record that there has been, as in the past, a most helpful cooperation on the part of all interested in the work of the office.

ZOOLOGY

The attention of the Zoologist, in the line of investigation, has continued to be directed to the study of the extensive Araneid fauna of the State. Supplementing the general account of the spiders of New York but preliminary to it, a revision of the family Pisauridae has been undertaken and is nearing completion.

Localities selected for field work have included regions of diverse topography in Orange, Ulster and Dutchess counties, and collections of considerable extent have been brought together. Concerning these it is proposed to prepare a separate report.

The report on the molluscan fauna of the State which has received the particular attention of Dr H. A. Pilsbry of the Philadelphia Academy, is now ready for the printer. Doctor Pilsbry's account is monographic in extent and illustrated with many beautiful plates executed in color and in black and white by Helen Winchester.

Dr Roy Miner, of the staff of the American Museum, whose researches on the myriapods of the State were interrupted by war activities, reports considerable progress in the preparation of his memoir.

New groups. The limitations of space in Zoology Hall prohibits the addition of many large habitat groups without a general rearrangement of the existing cases; but small groups of skunks and opossums designed to occupy limited floor space have been installed and other groups are in the course of preparation.

Through the interest and cooperation of the Conservation Commission, the State Museum has received by legislative appropriation, $1500 which will materially increase the collection of fishes from the fresh waters of the State.

The proper care and arrangement of the lesser invertebrates which are usually preserved in alcohol has always been of great concern to the museum curator. With the idea of making such specimens readily accessible and at the same time conserve storage space, a system of suspending small vials on vertical wire screens has been adopted. The supporting screens are filed in specially constructed cases of uniform size but adapted to receive vials of varying dimensions. By this method the handling of individual specimens or groups of specimens is facilitated, and the flexibility of the scheme permits indefinite expansion. Beneath the vertical files, drawer spaces provide room for larger jars of specimens and biological material.

Accessions. Benjamin W. Arnold of Albany, whose extensive collection of birds' eggs was presented to the Museum in 1917, has added an important series of specimens from the Falkland islands. The Henry A. Slack collection of birds' nests and eggs from the vicinity of Albany has recently been acquired through the courtesy of Miss E. Cary. The Museum has also purchased the skull of the extinct great auk to supplement the Shufeldt collection of avian skeletons already in its possession.

As an example of the persistence of certain large mammals in occupying, or perhaps reoccupying, well-settled territory, may be cited the capture of a Canada lynx in March 1920 by Isaiah Kilmer at Jackson's Corners, N. Y. The skull has been added to the collections.

Fragments of the remains of a fossil elephant (mammoth) consisting of skin, muscular tissue, adipocere and hair of varying lengths and texture from Alaska, were the gift of Langdon Gibson of Schenectady. Considerable interest is attached to these specimens because of their identity with the remains of the mammoth found within the limits of New York and because of their extraordinary preservation.

ARCHEOLOGY AND ETHNOLOGY

The work of the division of archeology and ethnology as has been explained in previous reports, covers several fields of activity and includes both field and office research. Beyond this, the nature of our subjects, touching human needs of the present day, places us in demand by several regular and some special branches of state service. Archeology and ethnology deal with the records of human activity, customs, material culture and social organization. Our Indian population with which we are especially concerned, still lingers with us and while constituting an interesting memorial of the past, also presents evidence of the virility and vitality of the Iroquois people. To some extent the existence of separate political units within the body politic creates special problems. Our endeavors thus reach from the most remote antiquity of the red race in this State to the newest of Indian babes.

The office routine of the year has consisted of the work of cataloging, making of labels, preparing of specimens for exhibition, study of records and the caring for requests by numerous correspondents. The fiscal year 1919–20 has brought an unusually large correspondence, indicating in no uncertain measure the value of this division of the Museum to the public and to the specialist.

Our catalog of archeological specimens is nearly complete and includes a serial catalog of all specimens acquired since 1911 and a cross check catalog by subjects. The subject catalog is of special value in determining the relative number of each specimen or class of specimens. The patient work of Howard Lansing, who died two years ago from an injury sustained while in the performance of his duties, has been continued by Harry C. Wardell, the preparator of the Museum.

The collections installed in the various cases have been cared for and certain special exhibits installed. These vary from time to time, as opportunity affords, in order to create public interest. During the winter and spring months the newspapers of Albany, especially the Times-Union, through the interest of Hon. Martin H. Glynn, have published extended accounts of these exhibits. This publicity swelled the crowds of visitors, especially those who came during the period of the Sunday openings. The large numbers of visitors and the appreciation manifested have served to stimulate up-to-date exhibitions and special displays.

The most recent large collection installed is that made by Alvin H. Dewey, Esq., of Rochester. This collection, described in the report of 1918–19, has been placed in the west room of Ethnology Hall. Special cases were made for it and both because of the class of material and the method of exhibition, the collection has attracted much interest and comment.

Public interest. There is a keen public interest in this section of the Museum as evidenced by the numerous visitors that come to our halls. We have sought to cater to the intelligence of the citizen who has not had the advantage of a special technical training in archeology and, at the same time, we have sought to make our exhibits instructive. The large number of letters received asking for information and assistance in various lines with which our subjects concern indicates that we are influencing an increasing field. Many visitors come to the office and give valuable information concerning sites and their location, and others bring or send specimens as donations to our collections.

In this connection it is interesting to note that at least 500 collectors of Indian relics and students of American Indian history and ethnology, within the State of New York, look to this section for information and guidance. Our bulletins are in constant demand and many of them have been entirely exhausted, pointing out the need of larger editions for future publications.

STAFF OF THE DEPARTMENT OF SCIENCE

The members of the staff, permanent and temporary, of the Department as at present constituted are:

ADMINISTRATION

John M. Clarke, Director
Jacob Van Deloo, Secretary and Director's Clerk
Anna M. Tolhurst, Stenographer

GEOLOGY AND PALEONTOLOGY

John M. Clarke, State Geologist and Paleontologist
David H. Newland, Assistant State Geologist, Curator of Geology
Rudolf Ruedemann, Assistant State Paleontologist, Curator of Paleontology
William L. Bryant, Honorary Custodian of Fossil Fishes
C. A. Hartnagel, Assistant in Geology, Curator of Stratigraphy
Winifred Goldring, Assistant in Paleontology
Charles K. Cabeen, Mineralogist
Esther K. Bender, Draftsman
Noah T. Clarke, Technical Assistant
H. C. Wardell, Preparator
Edith A. Lipschutz, Stenographer
Charles P. Heidenrich, General Mechanic
Stephen D. McEntee, Clerk
John L. Casey, Custodian of Museum Collections
William Rausch, Cabinet Maker
Jerry Hayes, Laborer
Edward Noxon, Laborer

Temporary Experts

Areal Geology

Prof. H. P. Cushing, Adelbert College
Prof. W. J. Miller, Smith College
Prof. G. H. Hudson, Plattsburg State Normal School
Prof. W. O. Crosby, Massachusetts Institute of Technology
Prof. George H. Chadwick, University of Rochester
Prof. Charles P. Berkey, Columbia University
Prof. A. F. Buddington, Geophysical Laboratory, Washington
Marion Rice, Columbia University

Economic Geology

Harold L. Alling, Columbia University
R. J. Colony, Columbia University

Geographic Geology

Prof. Herman L. Fairchild, University of Rochester
James H. Stoller, Union College
John H. Cook, Albany

Paleontology

Dr Rufus M. Bagg, Lawrence College
Florrie Holzwasser, Columbia University
Vincent L. Ayers, School of Mines, State College, Pa.
Herbert P. Woodward, University of Rochester
Joseph Bylancik, Albany

BOTANY

Homer D. House, State Botanist

Temporary Expert

Helen La Force, Schenectady

ENTOMOLOGY

Ephraim P. Felt, State Entomologist
D. B. Young, Assistant State Entomologist
Fanny T. Hartman, Assistant to Entomologist
Helen L. Ryan, Stenographer
Matthew J. McGarry, Page

Temporary Experts

Hall C. Carpenter, Massachusetts Agricultural College
William A. Hoffman, Cornell University

ZOOLOGY

Sherman C. Bishop, Zoologist
Benjamin Walworth Arnold, Honorary Curator of Ornithology
Arthur Paladin, Taxidermist

Temporary Experts

Dr H. A. Pilsbry, Philadelphia
Roy W. Miner, New York

ARCHEOLOGY

Arthur C. Parker, Archeologist

Temporary Experts

Everett R. Burmaster, Irving
William B. Moore, Victor
David Cook, Albany
George Stevens, Albany

ACCESSIONS TO THE COLLECTIONS

GEOLOGY

Donation

Luther, D. D., Naples
Slabs showing mud-flows and beach markings from Naples, N. Y.. 6

Finley, Dr John H., Albany
Photograph of moon, at last quarter, taken September 15, 1917, at Mount Wilson Observatory
Direct photograph of sun taken August 12, 1917, at Mount Wilson Observatory, showing distribution of sun spots.
Spectroheliogram of the sun showing its greatly disturbed surface. Taken at Mount Wilson Observatory August 12, 1917

Gould, Rev. E. W., Bristol, Vt.
Slab of Canajoharie shale showing glacial scratches from shore of Lake Champlain at Panton, Vt..... 1

Collection

Newland, D. H. & Alling, H. L.
Rock salt and brines from western New York..... 25

Newland, D. H., Albany
Iron ores of southeastern New York, magnetites, limonites and carbonates 50
Feldspar from Gailor quarry, Saratoga Springs..... 3
White quartz, Gailor quarry, Saratoga Springs..... 3
Strontianite from Brayman shale, Schoharie, N. Y..... 7
Pyrite from Brayman shale, Schoharie, N. Y..... 10

Colony, R. J., Columbia University
Quartz and quartzites from various New York localities..... 25

Alling, H. L., Rochester
Graphite from the Adirondacks..... 25

Hartnagel, C. A., Albany
Dark gray oolite ore with the spherules of chamosite. From thin band 1 foot below main oolitic iron ore at Clinton, N. Y..... 3

PALEONTOLOGY

Donation

Bryant, William L., Honorary Curator of Fishes, Buffalo
From Conodont bed (Genesee shale) eighteen-mile creek, Erie county:
Specimen with teeth of Dittodus priscus Eastman..... 1
Ptyctodus compressus Eastman..... 1
Dittodus minimus Huss & Bryant..... 1
Dinichthys magnificus H. & B. (Fragment of suborbital plate).. 1
Arthrodire or Stenognathus (plate)..... 1
Dinichthys newberryi Clark (marginal plate)..... 1

Bryant, William L.— *continued*

Machaeracanthus peracutus Newberry. Fragment of spine..... 1
Dinomylostoma buffaloensis H. & B. Functional portion of mandible..... 1
Ptyctodus calceolus Newberry. Imperfect dental plates..... 2
Ptyctodus howlandi H. & B. Fragment of upper and lower dental plate..... 4
Ptyctodus howlandi H & B. dental plates..... 3
Palaemoylus sp. Fragment dental plate..... 1
Aspidichthys notabilis Whiteaves. Fragment of plate..... 1

From Onondaga limestone, Buffalo, N. Y.:

Demodes bennetti H. & B. Fragments of dental plate..... 4

From Rhinestreet shale, eighteen-mile creek, Erie county:

Rhadinichthys antiquus H. U. Williams..... 1

Van Epps, Percy M., Hoffmans, Schenectady co.:

Disc-shaped concretions from Canajoharie shale 1¼ miles south of Glenville, Schenectady co..... 18

Mathes, K. B., Batavia

Elaeocrinus lucina (Hall), Stafford limestone, Stafford, N. Y... 1

Armstrong, E. J., Erie, Pa.

Fossil sponges from the Chemung sandstone near Erie, Pa..... 4
2 slabs of fossil crinoids..... 2
Gyrocers stebos Beecher. (cast) Upper Chemung. Conneautville, Pa..... 1
Large slab with specimens of Ceratodictya oryx Clarke. Lower Chemung, 9 miles south of Erie, Pa..... 1
Beach markings and worm burrows? Lower Chemung, near Erie, Pa..... 5

Simmons, Alfred, Saugerties

Specimen of Ancyrocrinus, Oriskany limestone, Glenerie..... 1

Robinson, W. J., Poughkeepsie

Normanskill shale, St Andrews Novitiate. Two miles north of Poughkeepsie..... 50

Bowman, Charles S., Hornell

Manticoceras pattersoni, Chemung beds, Hornell, N. Y..... 1

Burling, L. D., Ottawa

Ordovician (top of Deepkill) graptolite shale from Alaska-Yukon boundary..... 10
Caryocaris sp. 5 specimens. Graptolites 2 specimens..... 7
Deepkill shale at Alaska-Yukon boundary

Pohl, Erwin, Albany

Rysedorph conglomerate fossils from Rysedorph hill, Rensselaer county..... 225

Gould, Rev. E. W., Bristol, Vt.

Fossils from Trenton shale, Panton, Vt..... 70
Canajoharie shale, lake shore, Panton, Vt..... 60

Cole, Rev. Thomas, Saugerties

Oriskany (Glenerie) Glenerie, Ulster county..... 509
Onondaga. Split Rock, Onondaga county..... 2
Tully. Borodino, Onondaga county..... 4
Hamilton. Skaneateles lake 5
Hamilton. Mount Marion, N. Y..... 13
Schoharie Grit. Ulster co. (?) Loose Boulder (?)..... 41
Carboniferous. Mazon Creek, Ill..... 8

Powers, Sidney W., Tulsa, Okla.

Graptolites from Carter county, Okla. ..... 48 slabs
Fossils from Ordovician limestone, Carter, Okla..... 40 slabs

Jones, Leslie W., Amsterdam

One trilobite and three cephalopods, from Amsterdam limestone, near Amsterdam, N. Y..... 4
Fossils from Amsterdam limestone, Amsterdam, N. Y..... 9

Reinhard, E., Buffalo

Fossils from Ludlowville shale, Athol Springs, N. Y..... 6
Crinoid from Niagaran., Niagara Falls, N. Y..... 1

Ginn Bros., Mendon

Slab of white Potsdam sandstone with trails of Climachtichnites, probably a new species. From the glacial drift on the farm of Ginn Bros., at Mendon Ponds, Monroe county

Chadwick, G. H., Rochester

Mesopalaeaster sp. Four specimens on one slab. Chemung beds, near Rosses, Livingston co. collected by W. C. Bower..... 5
Hallaster sp. part of arm. Locality and collector same as preceding.

Hartley, Robert M., Amsterdam

Cryptolithus tesselatus Green. Five slabs with specimens..... 5
Amsterdam limestone in drift.

Clark, Burton W., Syracuse

Trenton and Utica fossils from Utica quadrangle..... 500

Exchange

Reinhard, E., Buffalo

Fishes from Onondaga limestone vicinity of Buffalo, N. Y..... 60
Rhinestreet shale. Eighteen-mile creek, Erie co., N. Y..... 8

Hibbard, Ray R., Buffalo

Slides of Ordovician bryozoans..... 35
Bryozoans from Ordovician of Ohio basin..... 13
Mounted conodonts from Conodont limestone of Genesee shale, Eighteen-mile creek, Erie co., N. Y..... 7

Ward's Natural Science Establishment, Rochester

British graptolites..... 19

Purchase

Ward's Natural Science Establishment, Rochester

Homalonotus delphinocephalus Green, Rochester shale, Lockport, N. Y. 3

Griffithides scitula Meek and Worthen, Pottsvillian, Brazil formation, Perryville, Indiana..... 1

Proetus missouriensis Shumard, Knobstone group. Clark co., Indiana. 2

Bumastus ioxus (Hall) Rochester shale, Lockport, N. Y..... 2

Lyriocrinus dactylus (Hall) Rochester shale, Lockport, N. Y.. 2

Life size model of the fossil horse (Eohippus)..... 1

Gillard, John, Stafford

Fossils from Stafford limestone, Marcellus shale, Onondaga limestone and Hamilton shale..... 1750

Reinhard, E., Buffalo

Pentremites, Loudlowville shale..... 2

Trilobites, Onondaga limestone, Williamsville, N. Y..... 5

Corals, Onondaga limestone, Williamsville, N. Y..... 2

Bertie Waterlime fossils, Williamsville, N. Y..... 5

Telson of Crustacean, Rochester shale, Lockport, N. Y..... 1

Macrostylocrinus ornatus, Rochester shale, Niagara Falls..... 1

Caryocrinus sp. Rochester shale, Niagara Falls..... 1

Pentremites, Hamilton shale, Athol Springs, N. Y..... 5

Megistocrinus depressus, Hamilton shale, Alden, N. Y..... 1

Pentremites maia (?) Hall Eighteen-mile creek, Erie co..... 1

Pentremites maia Hall Eighteen-mile creek, Erie co..... 1

Pentremites whitii Hall from Hamilton shale, Athol, Erie co.... 1

Gidley, J. W., Washington, D. C.

Six models of the fossil horse (1/5 nat. size) illustrating its evolution 6

Collection

Ruedemann, R. & Hartnagel, C. A.

Vernon shale from Barge canal excavation at Pittsford, N. Y. Material from under West Shore Railroad bridge..... 550

Hartnagel, C. A.

Oolitic iron ore fossils from Clinton, N. Y. All specimens show either the oolitic grains or were obtained from larger blocks which had ore attached. These specimens are from the top of the ore. 80

Fossils associated with blocky shale at base of oolitic iron-ore. Many specimens show the ore, usually separated from shale by a thin layer of pyrite. The specimens are all from a layer about six inches thick directly below the ore. Borst and Franklin Mines, Clinton, N. Y..... 50

Hartnagel, C. A., Wardell, H. C. & Pohl, E. R.

Clinton shale one-third of a mile due south of Verona Station. In brook below dam 20

Clinton shale 1 mile southwest of Verona Station. In small brook back of house of J. B. Weed, about 15 feet below the fossil ore (upper) 150

Hartnagel, C. A.

Clinton green shale. Red Creek, Wayne co. Creek bank at highway just north of railroad sta. These shales are above the heavy graptolite layers 27

Clinton shale, purple, including "pearly" limestone bands. From below upper Clinton Pentamerus limestone. Mudge creek, town of Wolcott, Wayne co 25

Clinton green shale and limestone bands at site of old Wolcott furnace 1 mile north of village. These beds are above heavy graptolite shales 6

Clinton upper Pentamerus limestone and from shale between the beds of limestone at Mudge creek near Wolcott, N. Y. 15

Clinton. Irondequoit shale and limestone in bed of Second creek north of Alton, N. Y. This locality shows coral reefs and the shale between the limestone layers is very fossiliferous 37

Clinton shale. From purple beds and "pearly" bands below upper Pentamerus limestone on Second creek near Sodus bay .. 25

Clinton, Limestone bands in green shale above dark graptolite layers. Second creek, Wayne co 12

Clinton upper Pentamerus limestone. Second creek, Wayne co .. 10

Upper Clinton Pentamerus limestone at Mudge creek, Wayne co. (from quarried stone used around boiler) 25

Clinton. Irondequoit limestone. From exposure in first small creek east of Wolcott creek, Wayne co 10

Lockport shale. 10 feet below Vernon red shale. Chadwicks, N. Y 25

Clinton, Donnelly quarry and ore pit now filled. Four miles north of Canastota 30

Clinton, dark shale just above the iron ore at Sterling Station, Cayuga co. 40

Clinton. Graptolite layers in Palmers Glen near Rochester, N. Y .. 20

Irondequoit limestone. From reeflike layers, Palmers Glen near Rochester, N. Y 10

Clinton, Willowvale glen (Rodgers). The specimens are all within 10 feet of the base of exposure about 300 feet west of highway .. 110

Clinton. Newland's Mill near Hecla Works. In shales approximately 20 feet below oolitic ore 10

Ruedemann, R.

Ordovician. Canajoharie shale, Fort Ticonderoga on road from railroad station to Ticonderoga 17

Ordovician (Canajoharie) shale at east shore at Willsboro Point .. 21

Ordovician (Trenton) shale at Stony Point 2 miles south of Rouses Point 41

Ruedemann R.—*continued*

Ordovician (Trenton) shale in town of Alburg, Vt., at Windmill Point..... 5

Ordovician (Trenton) shale in town of Alburg, Vt., at ice-house of Rutland R. R..... 34

Ordovician (Trenton) shale at Cumberland Head..... 44

Gould, Rev. E. W. & R. Ruedemann

Ordovician (Canajoharie) shale and Trenton limestone. Lake shore at Panton, Vt., north of Arnolds bay..... 53

Clarke, John M.

Thylacocrinus gracilis (Hall) Hamilton shales, Bethany, N. Y.... 1

MINERALOGY

Donation

Col. William B. Thompson, Cobalt, Canada

1 Silver and bismuth

J. B. Lain, Kennicott, Copper Co., Alaska

1 Chalcopyrite	Latouche, Alaska
1 Malachite	Latouche, Alaska

Purchase

Ward's Natural Science Establishment

3 Opals (precious) Virgin Valley, Humbolt co., Nevada

Wright, William K., Niantic, Conn.

A geode cavity partly filled with banded chalcedony (onyx) and lined with quartz of peculiar crystal form. From Desolation islands, off west coast of Tierra del Fuego, S. A.

Exchange

Holzman, John, Newark, N. J.

1 Hematite (specular)	Lake Superior, Mich.
2 Molybdenite in hornblende	Tintic District, Utah
3 Cuprite in chrysocolla	Tintic District, Utah
4 Stibnite	Elco, Nevada

Pope, F. J., Yonkers

1 Bornite	Magma Mine, Superior, Ariz.
1 Asbestos	Globe, Ariz.
1 Sphalerite on chert	Miami, Okla.
1 Polished lapis-lazuli	Cordillera de Ovalle, Chili, S. A.
1 Chalcocite	Kennicott Mine, Alaska

Mott, E. C., Yonkers

1 Malachite	Gila co., Ariz.
1 Azurite	Bisbee, Ariz.
1 Cuprite	Gila co., Ariz.
1 Malachite	Bisbee, Ariz.
1 Silver	Ontario, Canada
1 Annabar	Terlingua, Texas
1 Crysocolla	Gila co., Ariz.
1 Amethyst	West Paterson, N. J.

Ward's Natural Science Establishment

1 Tetrahedrite, pyrite and quartz	Bingham Canyon, Utah
1 Hematite (Kidney ore)	Cumberland, England
1 Chalcopyrite	Ugo, Japan
2 Opal in matrix	
2 White opals	
1 Fire opal	
4 Moonstones	
2 Tigereye	
2 Yellow chalcedonys	
3 Lead glass	
2 Quartzes	
2 Zircons	
3 Rhinestones	
2 Almandine garnets	
3 Amethysts	
2 Imitation amethysts	
2 Aquamarines (beryl)	
2 Synthetic sapphire	
1 Sodalite	
2 Lapis-lazuli	
2 Turquois	
2 Turquois in matrix	
2 Enamels (turquois imitation)	
2 Glass doublets (blue)	
2 Emeralds	
1 Brazil emerald (tourmaline)	
1 Ceylon peridot (tourmaline)	
2 Chrysolites (peridot)	
1 Epidote	
1 Bloodstone	
1 Jadeite	
1 Jade	
4 Doublets (green)	
1 Strontianite	Drensteinfurt, Westphalia
1 Franklinite	Franklin, N. J.
1 Sphalerite	Joplin, Mo.
1 Cryolite	Ivigtut, Greenland
1 Large gypsum crystal	Wayne co., Utah
1 Large malachite and azurite	Bisbee, Ariz.

Photograph of a "Relief model of Syracuse and vicinity." Published by the New York State Museum. The two improved state highways that make the phenomena described in the bulletin immediately accessible to motorists are indicated by heavier road lines.

THE TULLY GLACIAL SERIES

BY O. D. VON ENGELN

SCIENTIFIC PAPERS

Introduction

The purpose of this paper is to direct attention to and to describe a series of glacial phenomena that have a remarkable scenic and scientific interest and are also so easily accessible to large population centers in the State, and to tourists and students generally, that it seems strange that their significance has been hitherto almost overlooked.

The region in which these associated glacial phenomena occur is in the Finger Lakes district of the central part of the State and shares in the general scenic attractiveness of that section. Here are found rolling hills sufficiently high to be impressive and yet not so steep as to be an obstacle to motor travel. From many vantage points along the improved roads broad landscapes of field and forest-checkered slopes come into view and bold prospects across and along deep, steep-sided valleys are frequently encountered. In the latter the larger Finger Lakes are ensconced and in smaller hollows numerous lesser bodies of water are cupped. Thus a most varied and pleasing panorama is unfolded to the traveler and, whether he moves swiftly in train or motor car or goes leisurely afoot, he will find that very little of this panorama is monotonous, either in its broader aspects, as when seen from the road, or when studied intimately with a view to the interpretation of its details.

But aside from the general attractiveness of the region, that section of it which extends as a belt to the north and south of the village of Tully has long been a center of considerable interest to New York State students of geologic science. This section should also have an appeal for the very much larger number of residents of the State to whom it is easily accessible and who are of the group that derives pleasure in visiting scenic phenomena that are out of the ordinary.

Tully is located about halfway between the cities of Syracuse and Cortland, which are about 30 miles apart on a north-south line. An excellent state highway extends directly along this line and another of these highways intersects the first at Tully so that all the features herein described can be easily reached.

The Tully "Glacial Series"

The topographic situation of the features to be described is well shown in the photograph (plate 1) of a relief model of "Syracuse and Vicinity" published by the State Museum. While the model indicates very well the bolder features of the topography and the scenic diversity of the region, it was not made with a view to bringing into relief the particular glacial details of the landscape, hence does not show the features discussed in the following pages in so striking a fashion as these themselves present when seen in the field.

The Tully area exhibits compactly what has been termed by Penck and Brückner, in their work "*Die Alpen im Eiszeitalter*," a "glacial series." By this phrase it is meant to characterize the typical succession and association in which the various evidences of the occupation of an area by glacial ice will be encountered after the ice has melted away. Figure 1, adapted from Penck, shows the several

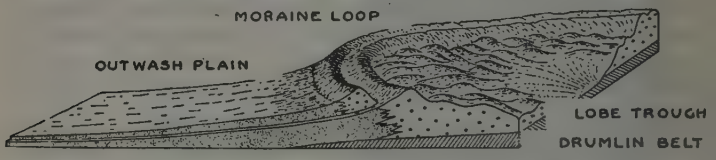


FIGURE 1. Diagram of the typical glacial series of the Alpine Glaciers. (After Penck)

members of such a series in their areal relationships and gives some idea also of the forms of which the series is comprised. Figure 2 is a reproduction of Penck's mapping of the actual occurrences of such a series on the Swiss plateau. In correlating the New York region, centering at Tully, with the Alpine area which these figures illustrate, Lakes Ontario and Onondaga would correspond with the Bodensee, the drumlin country and channels about Syracuse (drumlins are shown on the photograph of the relief model, plate 1) would match the drumlin and channel occurrences to the north and west of the Bodensee, the upper courses of the several rivers, Rhine, Danube etc. would be (less nearly) equivalent to the Finger Lakes valleys of New York and the Onondaga valley. The "Young End moraine" correlates with the morainic deposits at the heads of the Finger Lakes valleys, and, specifically again, to the barrier across the Onondaga valley west of Tully village, and finally, the small patches of "white-dot-on-black" symbol "Younger Deckenschotter" (outwash) outside the Young End moraine correspond to the much more

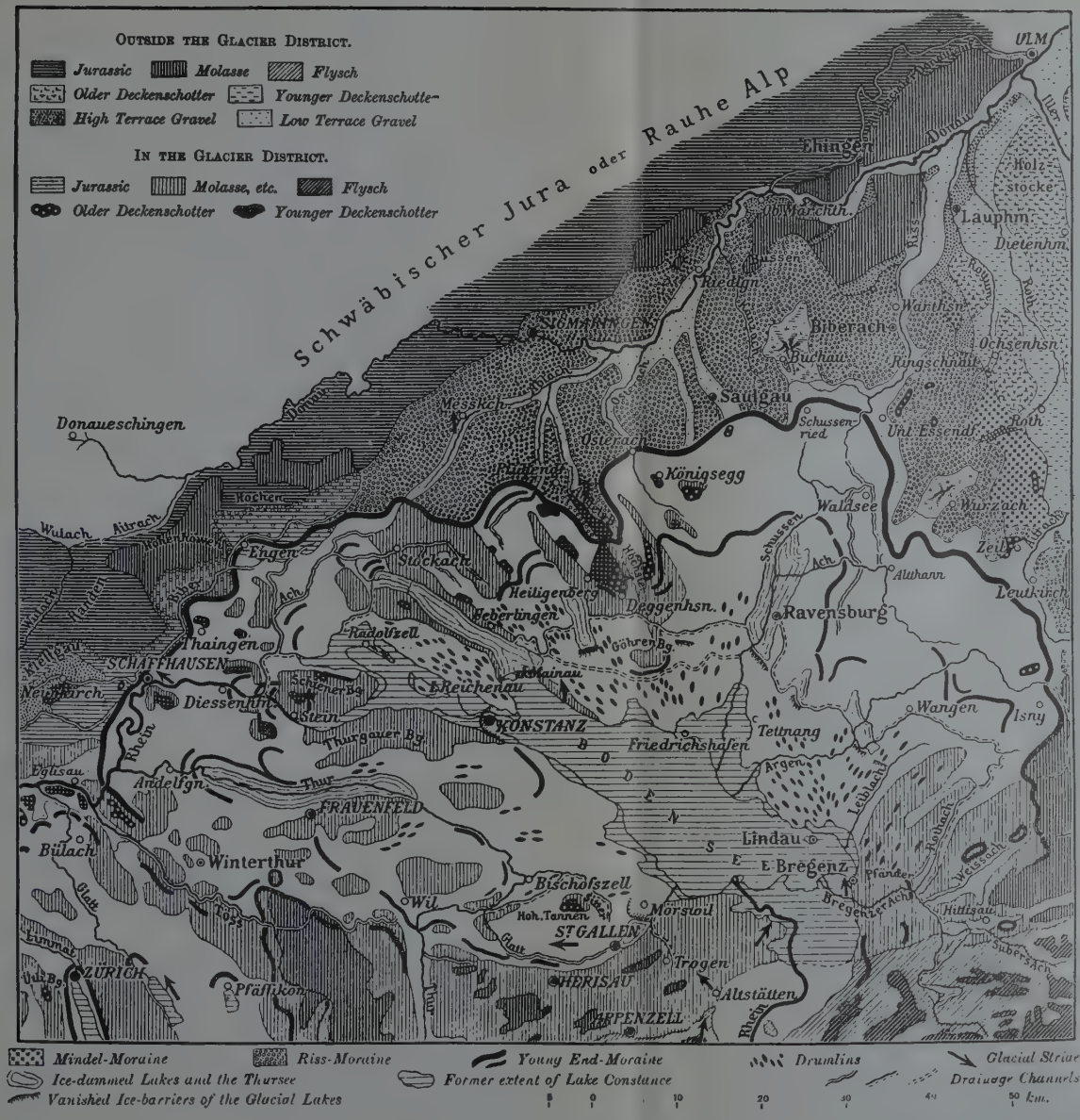


Figure 2 Map of the Rhine glacier deposits. (After Penck.)

extensive accumulations of such sediments on the south slopes of the continuations of the Finger Lakes valleys and, specifically once more, over the wide valley-flat south and west of Tully village.

While the correspondence in occurrence in both regions is sufficiently exact to be indicative of the typicalness of the succession, and in so far is suggestive, the two areas nevertheless differ in a number of respects. The Tully area has features that are lacking in the Alpine map and others that are much more characteristically developed than in the European region. The Tully area would therefore warrant separate discussion if only because of these differences. In pointing out such correspondence as exists there has been anticipated a general statement of the origin of these glacial series and, as such an explanation will be essential to a competent appreciation of the individual phenomena to be found in the Tully section, it follows next.

Development of the Tully Glacial Series

When the first advance of the glacial ice reached the Tully region it encountered a considerable topographic barrier, the northern escarpment of the Appalachian plateau, here formed by the outcrops, in an east and west belt, of the resistant Onondaga and Tully limestone formations. These are both massive rock layers in contrast with the soft shales which lie under each of them. Because of the greater resistance such massiveness gave these limestone layers when under attack by the agencies of weathering, frost and solution, they had broken down much more slowly than the shale materials; hence a cliff topography developed at the outcropping edges of the limestone layers. Such is the history of weathering escarpments generally and the Onondaga-Tully escarpment is no exception to this. Once these more resistant layers had been broken down over a given area, the soft shales beneath them crumbled rapidly and their fragments were borne away by the streams. Immediately to the north of the line where the limestones still exist a broad lowland was therefore formed, the Lake Plains; while to the south of this line the country, still capped and protected by these more durable rocks and also by the resistant Portage sandstones, kept a higher level and made the beginning of the upland areas which in their larger aspect are called the Appalachian plateau. The difference in elevation so caused is of considerable magnitude and well defined, and it may therefore be well termed a barrier to an ice mass moving down from the north. Thus the actual rise from Syracuse to Tully, going up over the edge of the

limestone outcrops and to the Portage sandstone summits is approximately 1600 feet in a distance of some 12 miles along a north-south line. The difference in elevation between the Lake Plains and the Appalachian plateau uplands is well shown in the photograph of the relief model (plate 1).

It must not be understood, however, that this escarpment presented in preglacial times a solid unbroken cliff. Drainage collecting on the upper levels and flowing down over the edge of the steep north-fronting outcrops in streams of considerable volume, cut notches in the edge of the cliff, which in time were deepened and widened into considerable valleys; and such valleys then were also extended back, or southward, by headwater erosion for significant distances into the upland country. Accordingly the escarpment in preglacial times probably presented a number of broad salients projecting northward separated one from the other by narrower valleys, widest at the north; and pinching out into the upland in the form of the letter V laid flat with its open end toward the north and drawn very tall and narrow. In a general way such has continued to be the topography of the escarpment front in glacial and postglacial time except that the valley feature has been much accentuated in depth, width and length and most extraordinarily modified in extension and form. The occasion for these changes in the valleys is to be found in the action of the ice.

In the movement of the glacial ice it would be manifestly improbable that the thin edge of its front, on encountering so high and steep a barrier as that of the escarpment described above, could be shoved up over such a slope and then across the broader uplands of the Appalachian plateau itself. It is evident, accordingly, that the escarpment slope acted as a dam, holding back the glacial flood until so much ice had been brought forward from the north as to make the ice thickness along the barrier as great as the height of the topographic obstruction. Only then could the glacial flow southward be recommenced in the form of a submerging ice sheet.

Meanwhile the water-cut and weather-widened valleys of the main streams draining to the north and notching the escarpment slope, themselves of considerable dimensions both as to depth and width, must have afforded channels into which the ice could thrust projections of notable length before the general front of the advance had overtopped the plateau level. As the ice became thicker and thicker such projections were elongated more and more and when the ice finally overflowed the upper levels the deepest and presumably most freely moving parts of the mass necessarily continued to follow the path-

10'
S A L I N A
Chestnut Ridge
Beartrap Creek
Ley Creek
CENTRAL AND HUDSON RIVER R.R.
YORK
Woodlawn Cemetery
Iron Piers
Salt Sheds
SYRACUSE
Oakwood Cemetery
Reservoirs
Elmwood Park
St Agnes Cemetery
SYRACUSE AND BINGHAMTON
Onondaga Hill
Onondaga Valley
East Onondaga
42 P.B.M.
43°00'
5'

ways opened by the stream channels. Such is the nature of the flow of the Greenland ice now through the gaps in the mountain rim that incloses the interior ice field of that vast island. The erosive activity of glacial ice is dependent for its relative effectiveness, primarily on the comparative thickness of the ice, and hence it follows that these north-south valleys, with their deeper and more rapidly flowing ice currents, were eroded at a much faster rate than was the general surface of the upland. As such differential erosion would tend still further to deepen and straighten the north-south channels, and so in turn facilitate the flow of the ice in them, it also operated progressively to accelerate the rate of the differential erosion along such lines. This combination of circumstances by concentrating the ice flow and hence erosion, ultimately resulted in the carving out of notable troughs in the mass of the plateau rock. At the head of the preglacial, north-sloping stream valleys there must have been a more or less rooflike ridge or divide separating the drainage that followed such valleys to the north from that which went down other valleys on the south slope. The ice tended to file down these ridge-divides, for the wedge form of such divides necessarily contained less mass of rock material than the unconsumed continuous masses on either side. Moreover such divides were right in line with the more rapidly moving currents, hence bore the brunt of the ice-erosion attack. Accordingly the preglacial north-sloping and south-sloping valleys were more or less regularly linked together by having their separating ridge cut away by the ice and thus were developed the characteristic *through valley* channels of the glaciated sections of the Appalachian plateau. The valley now drained by Onondaga creek to the north and by a branch of the Tioughnioga river to the south, with an *in valley* divide of glacial accumulation, at Tully, is a typical example of a trough of such origin, as are also the valleys of Butternut creek to the east, and of Otisco, Skaneateles and Owasco lakes on the west, all clearly illustrated on the photograph of the relief model (plate 1). Note also on this figure how the trend of the axes of the drumlin hills, extending from the northwest to the southeast toward Syracuse, lines up exactly with these through-valley troughs and so indicates that the direction of the general flow of the ice was exactly so oriented as to make these valleys the gateways for the movement farther south.

In the foregoing paragraphs the competence of the ice to erode the masses of solid bedrock over which it passed has been postulated without explanation of how this process acts. It is, however, essential to a clear understanding of the phenomena

consequent on such action that the manner of this be stated. As the ice first passed over the country from the north it picked up, and incorporated in its bottom layers, all the loose pebbles, boulders and sand and soil particles that covered the preglacial surface and moved these along southward. Moreover it pried loose projecting blocks of the bedrock material, where such occurred, and added these to its burden. Thus its bottom shortly became a rock-and-earth-studded ice mass, pressed down on the floor of the country over which it moved forward by all the thickness of the overlying ice. Since the ice eventually overtopped the highest of the Adirondack summits it must have ultimately attained a thickness of several thousand feet. After the unattached and projecting rock stuff had been removed, the later advances of thicker ice wedged and plucked loose fragments of the fresh bedrock; thus its bottom was continuously shod with boulders and also with scouring material of a finer sort. Aside then from its mass action as a plucking agent it is apparent that this boulder and sand furnished bottom-ice, pressed down by all the great thickness of the glacial mass above, must have been a grinding and scouring agency of immense effectiveness and hence been competent to carry away great quantities of rock material during the thousands of years that the ice occupied the country.

There was, however, a south limit to the ice advance, and there, as the ice melted, all the debris that had been picked up enroute was necessarily dumped. Some of it was heaped up in ridges along the front of the ice as it melted out; much of the finer material was carried away from the immediate front by the streams created by the ice melting. The heaped-up ridges of rock rubbish dropped by the glacier are termed *moraines;* the material carried forward from the front and distributed by streams is called *outwash.* As the glacial climate moderated and the supply of ice from the north was no longer sufficiently great to maintain the front at the southernmost latitudes reached at its maximum extension, the ice front itself receded, not by any *movement* backward, but simply by melting back faster than it could be supplied by flow forward. The interesting fact in regard to this amelioration of the glacial climate is that it apparently was not continuous, but occurred rather in distinct steps, so that there were successive halts and stands of the ice front east and west across the country. At each of these lines, where an equilibrium was established for a time between supply and melting, the rock rubbish was heaped up in moraines, and outwash deposits were formed, just as at the farthest front of advance; the mass of such accumulations depending on the length of time that the halt

continued. Where the equilibrium was established across a region of no great topographic irregularity, as in the central west of the United States, the front of the ice would have a relatively straight outline; but where the front, during a halt in the melting, rested over a region of notable relief, as in any part of the Appalachian plateau, it would be very irregular in outline for, as during the advance, tongues of ice would project far southward along the valley lines. This condition would in fact be much accentuated during the retreat of the ice, as the ice erosion during glacial occupation greatly enlarged these valleys in cross-section and made them straight and continuous over long distances north and south by obliterating the preglacial divides. Accordingly it may be conceived that long narrow lobes of the ice extended southward beyond the main front along such valley lines, while the hill country between had been melted clear of ice. On the summits the ice was thinner and also more stagnant, hence would disappear more rapidly than in the deep troughs with their greater thickness of ice and freer supply.

The point to this somewhat lengthy statement of conditions at the time of a halt of the ice, with reference to the Tully glacial series, is that such an equilibrium occurred just there and, jointly with the erosive action of the ice, was responsible for the phenomena exhibited in this section. About a mile to the west of the village of Tully and about a mile to the north there is encountered a very steep slope in the floor of the southward continuation of the Onondaga valley, a descent of some 300 feet within a mile. This declivity marks the inner side of a huge morainic accumulation made by a lobe of ice that extended up to this point in the valley and rested there for a long time. This declivity is not indicated very sharply on the photograph of the relief model (plate 1), but is a very marked feature on the topographic map of the region, plate 2, on which it is labeled "Tully moraine." It is shown graphically in the photograph (plate 3) taken from a point on the inner side of the moraine itself, just where the deposit joins the valley wall on the west side. The gentler slope to the south is the front of this moraine, and the wide flat plain with the lakes is the outwash accumulation that was formed at the same time.

References to the Tully Glacial Series in the Literature

Having gained now a general acquaintance with the glacial history of the region, it will be interesting to pause, before considering its special phenomena, to note such references to the area as occur in geological literature.

The close areal association of such a variety of glacial phenomena, and their intimate and interesting relationship as members of a connected series, and thus the unusual opportunity afforded in this region of comprehending a variety of glacial phenomena by field study, rarely afforded by so restricted an area, has in some measure been overlooked; but it must not be thought that the striking individual features exhibited here have altogether escaped the attention of geologists. Early in the history of the New York State Geological Survey, when the theory of continental glaciation had but recently been announced and had not yet gained wide acceptance; that is, at a time when geologists generally were much puzzled by such extraordinary accumulations of loose material as the moraines present, Vanuxem[1] writes:

> There is another class of deposits, well defined as to position but irregular as to composition, which are worthy of note. They occur in north and south valleys which are on the south of the Mohawk river and the Great level; or in other words, the Helderberg range forms generally the dividing line between their north and south waters. These waters anciently flowed in one same direction, through valleys still more ancient than themselves; but they now separate, and flow over double inclined planes in opposite directions.
>
> The whole of these deposits have a common character, they are in short hills quite high for their base, and are usually in considerable numbers. None were opened and no opportunity offered to ascertain if any defined arrangement of their materials existed or had been made when deposited. They consist of gravel, of stones also of greater size, sand, and earth. . . . In Onondaga valley there are two deposits . . . (the second) is a lesser deposit near the head of the valley (the Tully moraine). . . . The hills appear to have been formed by the waters of creeks when the lake was at a higher level for where such substances are deposited in deep and tranquil waters there is no tendency to diffusion [i. e. irregular, hummocky deposits].

It will be noted that Vanuxem assigned the morainic deposits to the action of rapidly moving stream waters; also that he failed to appreciate that the hillocks which he saw were but the surface excrescences of a much larger mass of material extending solidly between them and below them to the rock floor of the valley. This irregular surface expression of the moraine is very characteristically illustrated in plate 4, a photograph made on the summit of the Tully moraine on its east side just off the improved state highway that parallels the valley.

---

[1] Vanuxem, L., Natural History Survey of N. Y. 3d Dis't, 1842, p. 218.

View of the steep inner side of the Tully moraine. Seen from the west end of the moraine itself, near where this joins the valley wall. Looking southeast.

Characteristic hummocky surface of the top of the Tully moraine. Near its east margin, just off the improved state highway parallel to the Onondaga valley. Looking north.

In 1882 Chamberlin[2] notes that his assistant, R. D. Salisbury, "observed a very fine development of the chain (of moraine) in the Tully (*sic.*) valley." On the earlier page cited he states that he considers all the line of morainic hills, of which the Tully occurrence is a part, as the terminal moraine "of a very important advance of the great ice-sheet at a date considerably later than the stage of greatest glaciation, or, in other words, to outline the ice limit of a second glacial epoch." It will be noted that this interpretation is at variance with the one given in the preceding section of the present paper, where it is stated that the Tully moraine (and this statement applies equally to other moraines similarly located at the valley heads in the Finger Lakes region) marks, merely, a prolonged halt in the retreat by wasting due to melting and evaporation, of the last advance of the ice which extended at its maximum stage a considerable distance south of this line. It is possible that Chamberlin's inference is in so far correct that the *Wisconsin Ice,* as the last great advance is termed, had two phases, an earlier and a later forward movement, separated by a considerable time interval, and that the second forward thrust did not extend so far to the south as did the first. In that event the line of valley head moraine in the Finger Lakes region may mark the *near maximum* stand of the ice at the time of the second Wisconsin advance, but the opinion that it was the actual terminal of this ice does not now find general acceptance by glacial geologists.[3] If it were the actual terminus, extensive deposits of older, more weathered glacial material should occur immediately south of the morainic line, and this has not been observed. Moreover, other notable lines of moraine occur to the north, and the changes in the higher levels of the lake waters that preceded the present Great Lakes indicate that the withdrawal of the ice was, as postulated, by steps, and not a steady progressive melting away.

The authors of subsequent papers dealing with the effects of glaciation in this part of New York State, who make reference to the Tully area have been so engrossed in the work of tracing the glacial lake history of the region, following up the original suggestion made by the late G. K. Gilbert, that they give only incidental mention to other features. Thus Fairchild[4] refers to the heavy moraine that

---

[2] Chamberlin, T. C., The Terminal Moraine of the Second Glacial Epoch, Third Ann. Rep't, U. S. Geol. Sur., 1883, p. 357 and 302.

[3] See Tarr, R. S., The Physical Geography of N. Y. State, N. Y. 1902, p. 127–28.

[4] Fairchild, H. L., Glacial Waters in the Finger Lakes Region, Bul. Geol. Soc. Amer., 1899, v. 10, p. 57–58.

"extends from the divide at the Tully lakes northward for two miles . . . The moraine is very gravelly and the hills are really kames. . . . The small northern lakes seem to occupy kettles in the moraine filling. The outlet channel may be regarded as beginning below the lower lakes, Crooked lake and Tully (Big) lake, which have an elevation of 1193 and 1189 feet. These are shallow and probably lie in depressions due to ice blocks. The Tioughnioga valley, which heads at this point, will be discussed, with its heavy detrital deposits, at some future time." In another paper [5] the same author states that, "In the Onondaga valley the highest water was the Cardiff lake which had its outlet south through the Tully lakes," but it does not appear that the promise of publication on the features of the Tioughnioga valley has been yet redeemed. The most recent paper relating to the region is New York State Museum Bulletin 171, by T. C. Hopkins, entitled "The Geology of the Syracuse Quadrangle" in which there is a brief discussion of the channels and terraces of the Onondaga valley (p. 41-42) but no specific description of the glacial history of its south end is included. Inasmuch as this south end lies in the Tully quadrangle, its description would, indeed, not have been warranted under the title.

For a detailed record of the basic geology of the Tully quadrangle with a map showing the differentiation of the rock floor on which rest the superficial deposits here discussed, reference is made to Clarke, J. M. and Luther, D. D., New York State Museum Bulletin 82.

The Particular Phenomena of the Tully Glacial Series

Drumlins. The flow of the last advance of the glaciers, and presumably of the earlier advances as well, was turned by the Adirondack uplands from a direct southerly course into the Ontario basin and from thence the ice deployed southeast across the level lowland of the lake plains to the face of the Appalachian plateau escarpment described on preceding pages. The parallel orientation of the drumlin hills so markedly apparent in the photograph of the relief model gives a clear index of the line of motion of the mass, at least in its declining phases, and the fact that the ordering of the drumlins is in exact alignment with the valley channels opening southward into the plateau uplands is indicative that such was also the direction of flow during the major occupation.

---

[5] Fairchild, H. L., Pleistocene Features in the Syracuse Region, Amer. Geol., 36: 136, Sept. 1905.

The drumlins are the first item in the glacial series under discussion and may be seen in typical development about the southwest corner of Onondaga lake or in the area that comprises the southeast suburbs of Syracuse. Their nature and probable origin have been described at length in New York State Museum Bulletin 111 by Fairchild, hence will not be considered further here.

Troughs of glacial erosion. Turning again to the photograph of the relief map of the region it will be noted that four major valleys, from east to west, those of Butternut creek, Onondaga creek, Otisco lake and Skaneateles lake, and part of a fifth, Owasco lake, are shown, all of which have a general northwest-southeast trend and represent both the main channels of the ice movement and the work of erosional excavation wrought by the ice itself. On further inspection it will also be evident that the Skaneateles and Otisco valleys, which lie most directly in line with the ice motion, as indicated by the alignment of the drumlins, have been gouged out most deeply and uninterruptedly. In the area to the east, including what are now the Onondaga and Butternut Creek valleys, the drainage from the north face of the escarpment seems to have been only through valleys trending almost directly northward and, hence, at a distinct angle with the ice advance deploying southeastward. As indicated by the orientation of tributary valleys on the uplands, a major part of the drainage of this section was to the south, though, because of possible glacial and interglacial modification of their courses, only inferential reliance may be placed on this evidence. In any event, either because of the adverse trend of the preglacial north-sloping valley gaps with respect to the ice advance, or because these were smaller, there does not seem to have been in this section so effective and deep scouring action as in the valleys to the west. Hence, although the rock floor of the Onondaga valley is deeply buried under accumulations of glacial and stream transported débris, and ice erosion, accordingly must have cut down to considerable depths below the present surface level, ice erosion did not carve out a basin sufficiently deep to survive as a lake, as was the case with the two valleys to the west. Evidence that the ice flowed more freely and persisted longer in the lake valleys than in the Onondaga valley is afforded by conditions at the south ends of the lake valleys and is set forth below.

The Onondaga valley, though not so deeply cut as the lake valleys is, nevertheless, a typical example of a *glacially eroded trough* and, as such, is comparable to the valleys similarly carved in which existing valley glaciers of the Alaskan mountains, of the Alps, of the

Caucasus, New Zealand and Patagonia flow, and which they have formed by their particular erosive activities. There is this difference: the existing valley glaciers flow down their channels and are confined by them, whereas the Onondaga valley and the Finger Lakes valleys to the west of it were scoured out by ice *currents* in the main ice sheet of a continental glacier *flowing more freely up and through them* than over the upland spurs between the valleys.

That such through-flow produces a glacial trough having the same characteristics as those developed by valley glaciers is well demonstrated by the photograph (plate 5) of an ice-eroded valley on a *nunatak,* or projecting peak, of the barrier-mountain rim of Greenland; a valley the bottom of which is at a level above the present lesser development of the ice. The ice at a higher stage passed through this gap in a current from the main sheet, on the side from which the photograph was taken, toward the ocean. If the Onondaga valley and its continuation southward were dug free of all loose deposits its bedrock form would very closely resemble that shown by the Greenland valley. Such ice-eroded valleys have been typified as U-shaped in contrast with the normal V-shape of valleys due to stream-cutting and weather-widening. The comparison to the capital letter U is not altogether exact for it will be noted that the arms of the U in the Greenland valley (and of other glacially eroded troughs) are not vertical, but slope outward as would result if one should pull the U arms slightly wider apart at the top.

It is not to be conceived, as some observers seem to have thought, that these troughs in the Finger Lakes region were carved out by the projecting lobes of the ice in its retreating phase; neither was the cutting done by similar lobes in the advancing phase, nor even by one advance. The major excavation was probably accomplished when the ice attained a maximum thickness and extended solidly over the area in each of the several advances that may have occurred. The advancing lobes presumably scoured the initial paths but the retreating lobes probably did more, through deposit of detritus at their ends, to fill up the depressions than to accentuate them.

In one sense, however, the lobes of the retreating ice were responsible for the preservation of these troughs. By extending southward beyond the main line of the front they tended, for the duration of any marked halt in the withdrawal, to concentrate deposits in great masses at their ends, because all the ice slopes and their drainage from melting and precipitation tended to focus at such points. Hence, when, after a period of equilibrium between supply and wastage marked by a relatively fixed position of the ice front, there came

Glacial erosion trough, Sentinel Nunatak, Bowdoin glacier, west coast of Greenland. Trough scoured out by ice current when interior ice of Greenland was at a higher level. Illustrates typical cross-section of an ice-eroded valley. Photograph by William Libby.

Glacially eroded Onondaga trough, east side. Opposite the village of Tully Valley.

a period of more rapid wasting there would be a more than average rate of withdrawal in the lobate portions; for these projections may be likened to the dial hands of various gauges whose points swing over a wide range of degrees when their centers are only slightly displaced. A slight reduction and melting northward of the great bulk of the main ice mass would bring about a much greater lineal withdrawal of the attenuated, "sensitive" tips of the lobes, hence a more rapid one, and such process would tend to keep the portion of the trough in which the lobe had rested before comparatively free of detritus deposits made directly from the ice.

The Onondaga trough is a secondary and accentuated example of the lobe basin of figure 1. It corresponds most exactly with Lake Thur in figure 2. Minor projections of larger lobes rested in both hollows and their relatively rapid melting preserved the basin effect.

Hanging valleys. Genetically, however, the Onondaga trough is the result of ice erosion and it should be discussed as being of such origin. Its form, as seen from both sides, is well illustrated by plates 6 and 7, the former showing the east side, the latter the west side, both opposite the village of Tully Valley. In plate 6 note the level summit of the upland, comparatively little modified by glacial erosion, and the oversteepened slope of the Onondaga trough extending as a straight-line cut through the area. Plate 7, the west side opposite, shows the steep slope quite as clearly and illustrates another characteristic effect due to the differential action of glacial erosion, namely the creation of *hanging valleys* and the postglacial development of rock gorges on their lips. The cross-section form of the hanging valley and of the top of the postglacial gorge has been outlined in ink on the photograph so that the reader may be able to identify them clearly. The summit that appears in the distance in the center of the hanging valley depression is the hill, 1620 feet high, lying to the west of Maple Grove (Case P. O.) on the topographic map.

The thicker ice currents, moving freely through the valley channels with axes parallel to the general direction of the ice advance, notably deepened, widened and straightened such depressions during the course of the ice invasions, as is well illustrated by the Onondaga valley. Preglacial valleys with courses lying athwart the direction of the ice motion were, on the other hand, modified little if at all by the ice scour. In general with the rest of the upland country they were probably planed down somewhat but there was no concentration of erosive effect along their lines, and they may even have escaped the full erosion of the uplands; for their furrows would tend to obstruct

and stagnate the movement of the ice which filled them. Hence it came about that, on the melting of the ice, such east-west cross-valleys were left with their lower ends "hanging" far up on the sides of the much more deeply ice-eroded, north-south valleys to which they are now tributary. In preglacial time these east-west tributaries no doubt came into the main valleys *at grade*, that is, there was no declivity, waterfall or gorge at their junctions with the main valleys, because the preglacial weathering and stream-erosion processes of valley-cutting proceeded concurrently and accordantly in the main and tributary valleys, the smaller stream cutting down a narrow valley as fast as the large stream cut down a broader one. Moreover, as will be noted by the cross-section of the hanging valley in plate 7, this process of stream-valley development had proceeded to a stage of *maturity*, that is, there had been sufficient time for weathering to make the tributary valley wide open by wasting away the rock of its sides.

The present depth of the main valley below the level of the bottom of the mature hanging valley gives, therefore, a measure of the differential, glacial cutting-down of the north-south trough. The visible portion of this amounts to 600 feet in depth and the rock floor of the Onondaga trough is buried under loose drift of an undetermined thickness, probably more than 100 feet. It may therefore be safely reckoned that differential ice erosion lowered the bottom of the north-south Onondaga valley by some 700 feet. Plate 8 is introduced to illustrate the same process of hanging valley creation in a region of existing glaciation, but this example differs from the Onondaga occurrence in that both main and side valleys were subjected to ice erosion, the former by a deep and broad ice stream, the latter by a relatively thin and feeble one, hence the difference in the extent of their erosion and the creation of the hanging valley condition.

Postglacial gorges. After the last withdrawal of the ice the stream drainage of the present period was initiated. Where the tributary streams encountered the glacially developed, precipitous descents due to the oversteepened valley sides of the main trough, waterfalls occurred. As postglacial time passed these waterfalls, located on horizontally bedded stratified rocks of varying resistance changed from an original single straight fall, first to a series of step falls from one durable layer to the next and then, by recession of their cascade crests, after the manner of waterfalls so conditioned, there was cut a rock gorge in the lip of the hanging valley, as illustrated in plate 7. The occurrence of such rock gorges at the lower

Glacially oversteepened Onondaga trough, west side. Opposite village of Tully Valley. Crest line of upland broken by cross-section of the end of a hanging valley (marked by dashed ink-line) and the lip of the hanging valley cut into by a post-glacial rock gorge (top of which is indicated by a solid ink-line).

Hanging valley, Nunatak Fiord, Alaska. Both main and side valleys are glacially eroded, the former, however, much more deeply because of the greater effectiveness of the larger ice stream. Note notching of lip of hanging valley due to post-glacial stream erosion.

ends of the hanging valleys is the distinctive mark of a notable interruption in the stream erosion and weathering development of the side valleys; and the measure of the depth and enlargement of the side valleys indicates the degree to which the postglacial stream drainage has attained readjustment to the accordant slopes normal to purely stream-erosion and weathering cutting of valleys.

The morainic loop. Continuing up the trough valley there is next encountered the *morainic loop* or terminal moraine accumulation developed at the end of the Onondaga lobe during the halt period. This is at once the most conspicuous and spectacular feature of the glacial series, for it blocks the valley completely with a massive earth barrier. Its inner or northern side, against which the ice end rested, is so steep as to make it a very noticeable topographic feature.

Plate 3 shows this steep front as viewed from the west end of the moraine itself; plate 9 is a view also from the west side of the valley but from a point farther north along the Onondaga trough side, and therefore shows better the general configuration of the mass. The moraine makes a vast amphitheater of the head of the valley on its north side, with sides 300 feet high in the steeper upper part and a further slope of 200 feet more in the gently inclined portion at the base.

Against these slopes the ice tongue rested while discharging the material forming the moraine. The form of the slopes may, therefore, be regarded as a mold of the form of the ice itself for the depth up to which the moraine stuff was banked against its front. Beginning at the elevation of the relatively level crest line of the moraine, the ice is to be conceived as rising steeply northward, and within a few miles attaining sufficient thickness to fill the trough valley to the height of its bounding walls. This would mean that near the moraine front there was an ice slope of perhaps 400 feet down to the moraine summit.

The terminus of the lobe would thus have a very distinct wedge-shape, convex on both sides, like the blade of an axe made very thick behind the edge, the horizontal front edge of the wedge being disposed always along the crest line of the moraine during the progressive stages of its upbuilding in mass and height. Blocks of rock, melting out of the ice above the level of the crest at any stage, would roll and slide down the steep frontal slope of the ice until they lodged on the moraine; melting water would wash down the finer gravels and sand; drainage in streams of considerable volume at each margin of the lobe would sweep down larger quantities of such

material; and probably there was also upturning of the bottom ice layers so that these deposited their burden of débris on the inner side and on the crest of the moraine during its upbuilding.

The major portion of the material comprising the visible structure of the moraine seems to have been débris carried in the upper layers and on the surface of the ice lobe and aided in attaining its final position on the moraine in some degree by water transportation. Enormous volumes of water were continually being freed by the ice melting, not only at the lobe-end but also for a considerable area back from the front. Accordingly, it is not surprising to find that the superficial portions of the moraine are largely made up of water-sorted materials, sand and gravels coarsely stratified. On this account, too, the moraine, especially on its west side, has a distinctly kame structure. On the east side where the view shown in plate 4 was made, a much more characteristically ice-deposited hummock surface is found, and the cultivated field of the foreground of this picture shows the typical *boulder-clay* composition of such accumulations.

Kame kettles and hummocks. In a *kame moraine* the knobs and kettles are typically much more conspicuous than the similar hills and hollows resulting from direct ice-deposit of the glacial débris. The Tully moraine on its west side, as has been noted, has a kame structure and it also exhibits, especially along its south front, very strikingly and characteristically the *knob and kettle topography* of such accumulations. Indeed, few finer examples of this phenomenon could be found in all the accumulations of continental glaciation than occur in this section of the Tully moraine.

In origin the kettle or hollow, rather than the knob, is the determining factor of such topography, and the history of these hollows is another significant link in the chain of evidence connecting all the phenomena found in the region with the glacial invasions. As the moraine accumulated, deposit along the front of the ice was frequently much more rapid than the melting of the ice of a particular area. Hence it commonly happened that a block of ice was buried deeply under the gravelly débris. In such position it was effectively protected from melting as quickly as did the exposed ice areas adjacent to it. In time the buried block was completely detached from the ice tongue and persisted, unmelted, while additional masses of deposit were piled around and over it. When the detached ice blocks finally melted away completely the deposits over it must have sunk down to fill the cavity thus created. Such burial, melting and slumping must have constantly occurred while the moraine was forming,

Tully moraine loop, inner side. View from slopes of Dutch hill, lying off to the northwest from the moraine. Note the salt-well derricks on both sides of the valley at the base of the moraine. Summit of moraine made more distinct by retouching photograph.

Kame kettle on west side of south front of the Tully moraine. Coarseness of the material composing its walls is indicated in the photograph.

but the resulting hollows were then almost at once slushed full of other sediment. But during the very last period of the maintenance of the ice front at the moraine, the buried ice blocks apparently persisted until after deposit had ceased, and, on their melting out, the overlying débris caved in and formed the kettle hollows that are now so distinctive a feature. The material between one and the next of these, having a solid foundation, kept its original height and now forms the knobs of such topography.

One of the kettles, lying directly off to the north of the improved state highway crossing the south face of the moraine, is illustrated in plate 10. It is difficult to photograph such depressions so as to give a true expression of their shape. Thus the depression shown in plate 10 is almost circular and its foreground slope is nearly as steep as that of the background. The man stands at the bottom of the pit and his figure gives some notion of the scale; the hollow is approximately 75 to 100 feet deep. This one, and most of those on the upper levels of the moraine, contain no water; for the walls and bottoms of these are made up of such coarse material that drainage into them escapes under ground as rapidly as it enters. plate 11, however, illustrates a smaller kettle of the same origin, lying to the south of the road, in which water collects, because the finer clayey sediment found on these lower slopes of the moraine front is more impervious to downward percolation of precipitation.

South front of the moraine. Plate 12 is a view of the south front of the moraine from a point some distance up the slope of the valley wall on the west side. The gentle undulations of the cultivated fields and intervening forest areas, occupying the middle distance of the picture, are characteristic of the topography of this side of the accumulation. Here the material slid and slumped away from the crest of the moraine; much of it probably having the consistency of a wet concrete mixture at the time of deposit and therefore tending to build up a much gentler slope than that which marks the inner side of the moraine where the deposited material rested against and was supported by the ice during its shaping. This south-facing deposit, while occasionally sandy, has on the whole a much finer texture than that of the inner northern side; hence it is much better adapted to cultivation, and is the site of fine farms.

Lake overflow channel. When the ice front began to be melted back rapidly from its position at the moraine a great hollow was created between its retreating margin and the inner side of the moraine. Into this hollow water from the melting ice and from the drainage of the adjacent valley sides poured until the hollow was

filled up. This water could not escape northward, for there all the country was still solidly mantled by the glacier hundreds of feet thick; it could not escape laterally for the valley sides rose to elevations of 1500 and more feet. Accordingly its level was determined by the lowest hollow in the morainic barrier that had been built up across the valley and there the water of this local, *proglacial lake* overflowed to the south. To this body of water Fairchild has applied the name of Lake Cardiff.[6] The main overflow later may have been through a gap at an elevation of about 1180 feet that occurs just to the west of the road intersection north of Mud lake. But while the ice was apparently still blocking this lowest gap in the moraine an incipient lake seems already to have formed on the east side and its waters found escape through a gap at 1260 feet height, for the stream of this overflow made a very distinct and typical channelway, now altogether dry, parallel to the improved state highway leading north, just outside the village of Tully Center. On the topographic map this lake *outflow channel* is indicated by a tonguelike curve northward of the 1260 foot contour line. It is immediately parallel to the state road and is illustrated by plate 13, looking south.

The channel is seen on the left side of the picture and its cross-section form is most clearly discernible in the part between the barns on the right and the road on the left. Its right bank is in the loose morainic stuff and is most typical; the other bank is against the rock of the valley side.

The wide flat bottom and the low, though steplike, bank on the right are characteristic of such channelways. While functioning they flowed a stream of large volume continually replenished by the ice melting, which swept along its course in much the same way that the upper Niagara river on a larger scale now discharges the drainage of the Great Lakes. In the present instance the current was not so clear as is the Niagara water for it was derived from the ice-front immediately at hand, and this furnished a large quantity of sediment that was carried out of the small lake before it could settle to the bottom. Perhaps it would be better to class this scourway with what are termed *marginal* or *morainic channels,* for the ice influence and the sediment load the ice furnished no doubt gave it the predominating characteristics of this class, but, in its later phases at least, it must have had a lake fore-bay, hence may properly also be called a lake outflow channel.

---

[6] Fairchild, H. L., Glacial Waters in the Finger Lakes Region, Bul. Geol. Soc. of Amer., 1899, 10: 57–58.

Smaller kame kettle with standing water on lower slope of front of Tully moraine

South face of the Tully moraine. The village of Tully (not "Tulley Valley" or "Tully Center") is marked by the church steeple on the far side of the picture to the right of the center of the view. Note the gentle undulating slopes of this face of the moraine deposit.

Lake outflow channel on east side of Tully moraine. Leads down to village of Tully Center. Improved state highway leading to Syracuse on left. Note flat bottom and steplike bank on right in middle distance.

Outwash deposits. While vast quantities of the glacial débris brought forward by the Onondaga valley lobe were deposited in the moraine, as the vast bulk of this testifies, still more material was probably carried forward and southward by the waters released at the melting end of the ice and those which flowed along its lateral margins; for all the valley to the south of the morainic front is deeply filled with stream-sorted gravels, sands and clays, extending up to the levels of the moraine base at its south front and sloping thence gently southward for many miles. Thus was formed a vast *outwash plain* and a *valley train* that follows the course of the Tioughnioga river for many miles.

These deposits were formed by streams overloaded with sediment and during the same period that the moraine was being built up. On leaving the steeper slopes of the morainic front the velocity of such streams was at once appreciably diminished and they could not carry along all the detritus with which they were burdened. Accordingly, the coarsest materials, boulders and pebbles, were deposited first, and as the streams spread over their own accumulations, their flow was progressively less deep and more feeble so that successively finer deposits were laid down southward. Again, as their deposits built up their own beds and made these higher than the adjacent areas the streams were constantly shifting their channels to the lower points and building up these areas in turn. Thus eventually there was developed the wide, level plain illustrated by plate 14.

It must not be conceived that this outwash deposit was necessarily all built up from streams issuing from the ice immediately at the points where the morainic front is now seen. This morainic mass probably continues under the outwash for considerable distances southward and may indeed be made up of a number of ridges marking earlier halts in this section, as the visible mass marks the last stand. These possible and probable earlier corrugations of morainic material are, however, now all veneered over and buried under outwash. They must of course have been lower in elevation than the visible morainic mass at Tully, else they could not have been buried completely. But during the existence of each halt an apron of outwash was deposited along the moraine front, and as a succeeding, more northerly ridge was built up its outwash in turn filled in behind and built up over the deposits of both morainic and outwash material made previously.

Pitted plain lakes. Such composite and progressive development of the outwash deposits gives the clue to the origin of the singularly interesting and beautiful lakes, the Tully group and Little

York lake, that now occupy a considerable portion of the outwash plains. Part of Crooked lake of the Tully group is shown in plate 15; Little York lake appears in plate 20. As in the case of the kettles in the kame section of the Tully moraine these lake basins are the result of the melting out of buried ice blocks and the subsequent settling down of the superimposed material. Here the blocks seem to have been tabular in form, though irregular in outline, probably wide thin wedge-ends of the ice very quickly and deeply covered by the morainic and outwash accumulation. That such deductions are not wholly theoretical will appear on inspection of plate 16, where *pitted plain lakes* are actually in process of formation on a diminutive scale at the front of an Alaskan glacier. If one will recall how easy it is to store ice through the summer under only a thin cover of sawdust, it will be understood how ice blocks, detached from the glacier front, might persist for long periods under deep deposits of earthy material. In fact, experiments made on the surface of glaciers show that under even a slight rock cover the ice melts down only about two-thirds as fast as it does where freely exposed, a condition which gives rise to the phenomenon of glacier tables on many glaciers. These consist of an ice pedestal supporting a tabular fragment of rock which has protected the ice below from melting down as rapidly as the surrounding area.

The lakes in the Tully outwash plain are all shallow, as might be expected, but they have steep, though low shores. While the shores have not persisted through postglacial times in the perfection probably given them originally by the faultlike breaking down exhibited along the edges of such lakes in the Alaskan instance, the feature is still noticeable and is another point in support of this theory of their origin.

The several lakes are scenic features of much charm and in years before the vogue of motor travel were summer resorts that attracted numerous cottagers. While they continue to function in this way in some degree the upper ones now also serve another economic purpose. Water is piped from them through the Tully moraine and on the lower slopes of the moraine flowed into wells which have been drilled down to the salt strata in the bedrock. As saturated brine the water is pumped out of the wells and then conveyed by gravity flow to the notable chemical industries of Syracuse adjacent to Onondaga lake. This brine is the basic raw material for these industries. The continuous gravity movement of the liquids that the topographic relations make possible is a geographic factor of more than small importance in the success of the industry.

Tully outwash plain. View from the east side, looking south from the improved state highway on the lower slopes of the south face of the moraine.

Crooked lake of the Tully Lakes group. As seen from the valley side on the west. Occupies a depression in the outwash plain, which extends across the picture to the east valley wall. A glimpse of Big lake is visible in the distance.

Pitted plain lakes forming in front of the Hidden glacier, Alaska, 1905. Note the level surface of the outwash deposits and the breaks where the gravels have slumped down, due to the melting out of buried ice. In the bottom of some of these lakes unmelted parts of the ice blocks could be discerned.

History of the Tioughnioga river. Up to this point the discussion, with the exception of the emphasis put upon the notable succession of the glacial series features found in the area and the regional descriptions, has not involved anything especially novel in the interpretation of glacial phenomena or physiographic history. The reader has, however, now been sufficiently informed in regard to the general succession and relation of the features exhibited, to be in a position to appreciate a set of conditions which have given the course of the Tioughnioga river peculiarities that have unusual significance in the interpretation of the last phases of the glacial development of the area.

The Tioughnioga river has its source in Big lake of the Tully Lake group. Probably Crooked lake and Long lake also underdrain to it, for they stand at a slightly higher level than does Big lake. Reference to the topographic map will reveal the fact that almost immediately after leaving the Big lake source the course of the river bends sharply over to the east valley wall of the outwash plain and continues to parallel the valley side for several miles. In this section, parallel to the valley and alongside the improved state highway, the river cuts directly into the rock wall of the larger depression. Then the stream passes through Little York lake, meanders for some miles over the valley train deposits and next, opposite Homer, it again swings sharply against the east valley wall. What is the significance of these two swings with a course close up against the bedrock of the valley side in each case?

Reference to the photograph of the relief model of the region (plate 1), in conjunction with use of the topographic map will make it evident that the place where the first of the swings occurs is just opposite the mouth of the Otisco lake *through valley,* marked at its end by the village of Preble. Similarly the swing at Homer is the end of the Skaneateles lake through valley. Both of these lake valleys have a history equivalent to that of the Onondaga valley. They are glacially eroded troughs even more deeply and sharply incised by the ice than the Onondaga valley.

Apparently, also, they were occupied longer by the ice than was the Onondaga valley. This might be expected since they were more directly in line with the axis of the ice advance, as pointed out earlier, and were cut deeper and straighter; hence they could hold a more actively supplied and deeper lobe of ice during the retreatal stages. But more significant than such inferences is the fact that beyond the south end of each of these valleys there is spread a wide fan of outwash material, which lies higher on the west and slopes off in

alluvial-fan shape across the Tioughnioga valley. Because such filling, then, makes the valley bottom highest on its west side the course of the stream is pushed sharply over against the east side of the valley and made to outline the form of the fans on the north and south. The deposit at Preble is clearly shown in plate 18 where it is seen rising with relatively steep slope up the valley opening in the center of the picture.

In other words, after the outwash from the Tully lobe had been built up to its maximum level, heavy outwash deposits were still being brought out of the Otisco and Skaneateles valleys and dumped on top of the Tully outwash plain where these valleys had outlet to this plain at their south ends.

It may be argued that these deposits are of postglacial date, and hence that the pushing of the Tioughnioga stream against the east side of the valley may also have been a recent occurrence and not contemporary with ice-waning phases of the glacial occupation. Such a deduction is, however, opposed by several lines of evidence.

If of postglacial origin the deposits at the mouths of the valleys would nevertheless need to have been stream-transported. Yet there is no drainage down the southeast slope of the Otisco valley ending at Preble at all competent to build up such a mass. The small stream that does emerge from the valley is apparently itself guided in its course by the outwash accumulations, for it skirts their south edge and empties into Little York lake. While this applies with less force to the conditions at Homer, for Factory creek is evidently a stream of sufficient length and volume to transport considerable sediment, sufficient proof that it did not make this deposit is found in the fact that Factory creek is an eroding, and not a depositing, stream in this section and has cut a notable channel through the outwash itself; is, indeed, engaged in clearing it away.

Finally, the nature of the channel of the Tioughnioga stream itself gives evidence that it was developed under different conditions from those that now prevail. On comparison of plate 19, which shows the Tioughnioga river in the section where it is forced to flow close to the east valley wall (on the right), with plate 13 of the abandoned lake outflow channel across the Tully moraine, it will be perceived that these have essentially similar characteristics. The Tioughnioga river in this section has the channel peculiarities of a lake outlet stream, and such indeed it is. But the existing stream is "underfit" (to use a word coined by Prof. W. M. Davis of Harvard) in that it flows over the bed of the channel in wide shallows and has not, under the existing conditions, either the volume or the

Shore of Crooked lake, west side. Illustrates low, but steep, descent from outwash plain level to lake surface.

Otisco valley outwash fan spreading over the Tully outwash deposit. The Otisco fan occupies the valley opening in the background of the center of the picture. The view looks over the northeast arm of Little York lake. The village of Prable is situated just at the base of the rock hill at the extreme right in the picture.

Tioughnioga river where forced over against the East valley wall by outwash from the Otisco valley. Note the broad, flat-bottom nature of the channel and its gentle gradient and the evident "underfitness" of the present stream which covers the channel bottom with only a shallow current.

Truncated spur between south end of Otisco valley and Tioughnioga valley. Truncated part is the steep forest covered slope, back of expansion of northeast arm of Little York lake, which appears in the left center of picture.

velocity to carve out the depression it occupies in part. The lakes which are the source of the present stream are of sufficient area to equalize the rainfall run-off discharge of their drainage area so that the stream does not fluctuate between flood and drouth as would normally be the case with a stream not having such storage reservoirs at its head. Hence it may be assumed that the stream never fills its wide channelway to the banks, as indeed is evidenced by the fact that very low bridges have been built across it, houses placed near the water's edge and that forest trees have grown up in the channel bottom.

It appears, therefore, that the Tioughnioga channel in this section was formed when the stream carried a much larger body of water, that is, when it was fed primarily by the outflow from the Cardiff lake, ponded behind the Tully morainic barrier. This water was probably relatively free of débris when it reached the part of the Tioughnioga course under discussion but here it probably received accessions of sediment-laden water coming over the Otisco outwash. At a later date this water, too, may have cleared up on becoming the outflow of the highest level lake in the Otisco valley and the combined volume of two such large drainage basins would suffice to create a stream of considerable magnitude, one that could amply fill the channel from bank to bank and scour out a typical flat-bottom lake outflow course.

Truncated spurs. One feature of the topography due to the glacial occupation yet remains to claim attention. This is the conspicuous facetting of the slopes of spurs that formerly projected with rounded shoulders into the main valley, but which have been planed off by the ice erosion so that the through-valley Onondaga-Tioughnioga depression now has a straight line course. On the topographic map the *truncated spur* phenomenon is well illustrated by the east side of Toppin mountain across the valley from Preble and again on the spur to the north of Preble. In the photograph (plate 20) are shown both the upper end of the Tioughnioga (south continuation of the Onondaga valley) valley (on the right) and the south end of the Otisco valley (on the left) with the rock hill of the divide spur rising between them. The summit and the hollow on the south side of this spur, the lee slope with respect to the glacial onset, preserve, essentially, the preglacial contours of the country in their soft, rounded, mature curves. The east end, however, has been abruptly cut off, as though sliced through with a huge knife, and this is a characteristic feature of such spurs where they were affected by the ice scour. While difficult to photograph effectively, such spurs are a very conspicuous element in the scenery of the area and arrest the attention of even the casual tourist.

Conclusion

The above account by no means includes all the interesting features of the physiography of the region. A whole bulletin might well be devoted to tracing the preglacial, glacial and postglacial drainage history of the area. But this paper will have served its purpose if it has brought to the reader a realization of the extraordinary variety of glacial phenomena the section exhibits, all of typical and even magnificent development, and within very narrow areal confines. With the one notable exception of *eskers,* every significant development due both to the erosional and depositional work of the continental glaciers is here visible, and not only that, but also among surroundings of the greatest scenic attractiveness and in situations immediately accessible from the State's improved highways. It is hoped that the publication of this paper will help to make the area deservedly well known to increasing numbers of those who wish to understand as they go.

PALEONTOLOGIC CONTRIBUTIONS FROM THE NEW YORK STATE MUSEUM

BY RUDOLF RUEDEMANN

The following notes are written to direct attention to some of the observations of broader interest made by the writer in recent years, mainly in connection with the monographic treatment of the Upper Ordovician of New York;

They deal with the following subjects:

1 Homoeomorphic development of so-called species and genera of Graptolites in separate regions
2 On sex distinction in fossil Cephalopods
3 On some cases of reversion in Trilobites
4 On color bands in Orthoceras
5 A new Eurypterid from the Devonian of New York
6 Preservation of alimentary canal in an Eurypterid
7 Note on Caryocaris Salter
8 Fauna of the Dolgeville beds
9 Additions to the Snake hill and Canajoharie faunas
10 The age of the Black shales of the Lake Champlain region
11 The Graptolite zones of the Ordovician shales of New York

1 Homoeomorphic Development of So-called Species and Genera of Graptolites in Separate Regions

We wish to state here a clear case of the development, in the same direction but in separate regions, of several forms from a common species.

The axonophorous graptolite Glossograptus quadrimucronatus has a worldwide distribution. It was first described by James Hall[1] from the Gloucester ("Utica" shale) of the Lake St John district in Labrador, but is now known from numerous localities in eastern Canada and New York, as well as from Scandinavia, Great Britain and Australia (Victoria). In the Lake St John district the type form occurs in beds of late Utica age, and in New York this form is found in the Atwater and Deer River shale of late or post-Utica age. In Europe it occurs in beds of

[1] For bibliography, see Ruedemann, Graptolites of New York, pt. 2, 1908, p. 385.

about the same age (zone of Pleurograptus linearis). Earlier mutations appear in New York in beds of Trenton age (Canajoharie and Schenectady beds). One of these is characterized by two long spines at the sicular end (mut. cornutus).

In Glossograptus quadrimucronatus all four sides or edges of the prismatic rhabdosome are furnished with a row of spines each, two spines flanking each aperture. These spines are of nearly equal length throughout and were obviously a protective measure.

The Utica shale at Holland Patent and South Trenton has afforded a peculiar mutation that is characterized by spines of double length (2 mm +) that are found opposite the sixth or seventh pair of thecae, sometimes also opposite the fifth to seventh pair. In this peculiar character the form exactly corresponds to the var. spinigerus Lapworth of Glossograptus quadrimucronatus (see Elles & Wood, p. 223), which singularly enough occurs at the same horizon, that with Pleurograptus linearis in the Hartfell shales of Scotland. In this vicarious form of Scotland, however, the longer spines appear at about the tenth pair of thecae. A third form has been described by T. S. Hall (1906, p. 277), from Victoria, Australia. This has four prominent spines about 2.5 mm long at about the seventh or eighth thecae.

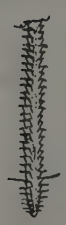


Fig. 1

Fig. 2

Fig. 3

Figs. 1–3 Glossograptus quadrimucronatus (Hall). Fig. 1: Mutation from the Utica shale at Holland Patent, N. Y.; fig 2: The variety spinigerus Lapworth (from Elles and Wood); fig. 3: Mutation from Victoria, Australia (from T. S. Hall).

A fourth mutation has been observed in the Utica shale of Herkimer county, in an earlier horizon than is exposed at Holland Patent In this form, in which the rhabdosome is abnormally large, the longer

spines (over 3.3 mm long) correspond to the seventh to ninth pair of thecae, in the specimens observed.

We have thus four mutations of Glossograptus quadrimucronatus which appear at about the same time and which are all distinguishable by one or several rings of greatly lengthened spines, some distance from the sicular end. When less closely observed, all four would be readily taken for one or the same mutation. The Holland Patent mutation bears, however, the longer spines at the fifth to seventh thecae, the Herkimer county form at the seventh to ninth pair, the British form at the tenth pair and the Australian form at the seventh or eighth pair.

It is not possible that the Herkimer county form is identical with either the British or the Australian one, for it still differs from both though less widely than the Holland Patent form.

There are thus four different mutations of the species which have developed at practically the same time in the same direction, namely, the enlargement of a ring of spines. In Great Britain there occurs, further, a very closely related species, Orthograptus pageanus var. abnormispinosus Elles & Wood which, at the same time, also bears a ring of four longer spines, at a similar distance from the sicular end.

There existed thus some stress or tendency which led independently in widely separated regions to the development of similar or homoeomorphic mutations which, however, are not identical, as proved by the slightly different location of the rings of spines. If by accident, the rings had appeared at the same level of the rhabdosome, those mutations would be indentical although they had originated independently and separately in different regions, as proved by the fact that they do not occur together in any of the regions, which, in that case would constitute the center of distribution. One naturally asks, Have such cases not happened oftener and the forms been thrown together into one species of wide distribution, because the original differences, denoting independent evolution, have failed of observation? It would then seem possible that even the same species (or what to our crude discernment appears as one species, but really is not), may at times have originated in several separate regions independently, a possibility that has been repeatedly denied by students of the principles of evolution. It would be only necessary, it seems from the case here described, that a species of worldwide distribution, be exposed to the same influence or stress at separate places and then respond in exactly the same manner. It could also be urged that there might have existed a tendency to a development of

these longer spines, which made itself felt at different places, but this assumption is negatived by the fact that the mutations here mentioned did not persist at all, but disappeared again as suddenly as they had appeared. They are therefore more probably of the nature of devices to increase the equilibrium or the floating surface of the rhabdosome; devices that, however, were impracticable in other regards and thus led to aberrant types.

The case here described of the independent development, in separate regions, of forms that might be brought together as one mutation and even as a new species, is but the expression in a smaller way of a process that, acting in diverse regions upon numerous species, has led to the evolution of polyphyletic genera of graptolites.

The heterogenetic, homoeomorphous development of the most important genera of the Dichograptidae from Clonograptus and Bryograptus successively through Dichograptus, Tetragraptus to Didymograptus has been early recognized by Nicholson and Marr and their phyletic lines of species have been traced by Elles in the case of the British species through these "genera" and by Ruedemann for the American species. The result of these investigations is that the genera Clonograptus, Bryograptus, Dichograptus, Tetragraptus and Didymograptus are undoubtedly polyphyletic; and represent stages of parallel development in many "phyla" or genetic lines of species (see p. e. table of New York State Museum Memoir 7, opposite p. 554) showing the phylogeny of the species of American Axonolipa or earlier graptolites without axes, leading from multiramous irregularly branching forms (Clonograptus, Bryograptus) through multiramous regularly branching forms (Dichograptus) to pauciramous symmetric forms (Tetragraptus and Didymograptus). The explanation for this remarkable parallelism is sought in the suggestion that symmetry in the arrangement of the branches would tend to insure an equal supply of food to each branch, and that the fewer the branches the greater the supply of food to the entire organism.

As in the case of the mutations of Glossograptus quadrimucronatus described above, also the development of the homoeomorphous groups of Dichograptus, Tetragraptus and Didymograptus has been going on independently in the various oceanic basins, or even different parts of the same basin; as is suggested by the different genetic lines observed in eastern North America and in Great Britain. Nevertheless the new "genera" seem to appear at the same time in the different oceans and the development to be thus strictly parallel and everywhere persistently

in the same direction, namely, toward less branches and more symmetric colonial stocks.

This development of the Lower Ordovician axonolipous graptolites is thus typically orthogenetic, as the result of persistently acting exterior factors such as the advantages of equal distribution of food to all branches and the attainment of equilibrium of the floating rhabdosome by symmetric and uniform development of all branches.

The present writer has distinguished ten lines of development of graptolite species among the New York forms from Clonograptus and Bryograptus through Tetragraptus to Didymograptus, which can be traced to at least four different species of Bryograptus and Clonograptus (Goniograptus). There should then be recognizable here and in time named at least four generic groups of Tetragraptus and ten of Didymograptus.

Taking our example of the Lower Ordovician graptolites of New York, we get the following phylogenetic diagram of these earlier graptolites.

It would lead to a bewildering and complex nomenclature if we should attempt to recognize all these racial lines and stages by sep-

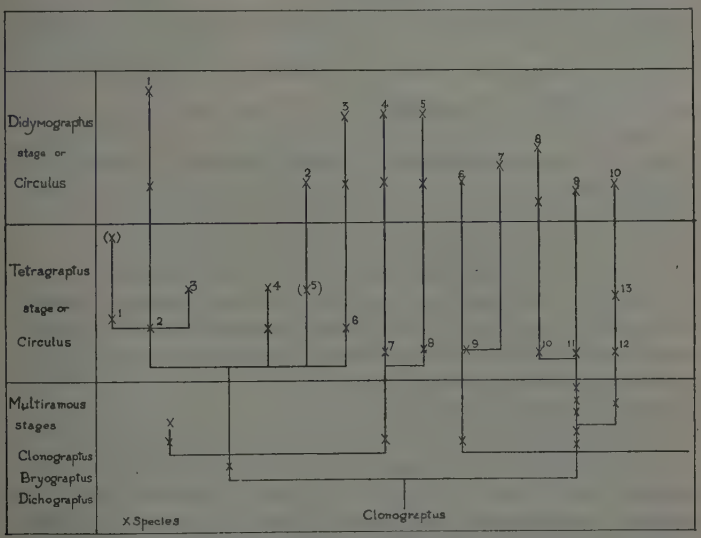


Fig. 4 Phylogenetic diagram of the American axonolipous graptolites; the figures representing the number of species.

arate names, as an attempt to do so in the case of the goniatites has shown, but it would be perfectly possible to name each racial line by its terminal member, as line 1 of our diagram that of Didymograptus forcipifer, and retain for practical reasons the polyphyletic "genera" Tetragraptus etc. with the understanding that they are not true genera. The writer has proposed (in Memoir 7, 1904) to term them "Geologic genera," while Gregory's better term "circulus" has come into use for these groups of homoeomorphs.

Similar conditions seem to prevail also among the axonophorous graptolites where the genera Diplograptus, Climacograptus and Monograptus apparently fall into racial lines.

We have then here the same phenomenon of polyphyletic development of "genera" so well known from the ammonites and brachiopods through the investigations of Buckman and others, and also recognized among the vertebrates, as in the case of the development of the horses in America and Europe.

Bibliography

Hall, Geological Survey of Canada. Figures and Descriptions of Canadian Organic Remains, decade 2, 1865

Nicholson, H. A. & Marr, J. E. Phylogeny of the Graptolites. Geol. Mag. dec. 4, v. 2, 1895

Elles, G. L. Graptolite Fauna of the Skiddaw Slates. Quar. Jour. Geol. Soc. 54: 529, 1898

Hall, T. S. Reports on Graptolites. Rec. Geol. Surv. Australia v. 1. 1906. p. 266

Elles, G. L. & Wood, E. M. R. Monograph of British Graptolites; ed. by C. Lapworth

Ruedemann, R. Graptolites of New York, pt 1, p. 553. 1904

Grabau, A. W. Principles of Stratigraphy, New York, 1913.

2 On Sex Distinction in Fossil Cephalopods

The upper Utica shale at Holland Patent contains in close association in the same bed, three different forms of breviconic cephalopods, namely, a larger and a smaller form with contracted apertures and a smaller form with open aperture. According to the usual procedure, these would be distinguished as different species; the first two as belonging to Oncoceras, the third as a Cyrtoceras.

The fact that both the larger and smaller forms with contracted apertures exhibit more closely arranged septa just below the living chamber, indicates that the contracted aperture actually indicates a gerontic condition and that both forms, the larger and smaller, had reached or passed maturity. Outside of this difference in size, the two forms agree absolutely in all other characters, as relative rate of

growth, depth of septa and camerae; and likewise does the third form with wide open aperture fail to exhibit any other differences suggestive of specific separation. This third form is also of smaller size.

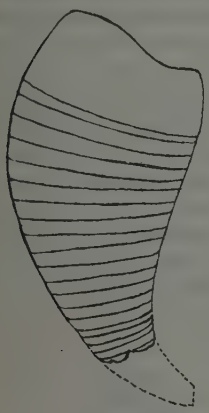


Fig. 5

Fig. 6

Fig. 6*a*

Figs. 5–6*a* Oncoceras pupaeforme nov. Fig. 5 Mature female; fig. 6 Mature male; fig. 6*a* Immature female.

We consider these three forms as belonging to a single species (to be described in a later publication as Oncoceras pupaeforme n. sp.); the larger and smaller forms with contracted apertures representing the mature females and males, and the smaller forms with open aperture the immature females.

The conclusion that the larger shells contain the females of the species and the smaller ones the males, is based on the observation that in the cephalopods (E. Ray Lankester, V, p. 319), "as a rule the males are more slender (e. g. Loligo media) or smaller than the females." In Argonauta, where the maximum of sexual dimorphism is found, the females are as much as 15 times as long as the males.

In Nautilus, which would be the nearest relative among recent cephalopods to use for comparison, the difference between the conchs of the two sexes seems to be still subject to some doubt. Bashford Dean (1901, p. 819) describes the shells of the females as frequently a little more arched and ventricose than those of the males, while Willey, on the contrary, considers the narrower and higher shells as the female ones. Other authors (see Ray Lankester, loc. cit.)

describe these cephalopods as larger and the aperture of the shell as wider in the male than in the female.

Emphasizing the general observation of the larger size of the females among the cephalopods, we incline to accept Dean's view and especially do not believe that the doubt still expressed as to the relative size of the shells in Nautilus militates against our conclusion that the two different sizes of the mature conchs in Oncoceras pupaeforme can be ascribed to sexual differences and that the larger form most probably represents the female. D'Orbigny, noticing that there were two varieties of almost every kind of ammonite, one compressed, the other inflated, assumed that the first were the shells of male individuals, the second of females (see Woodward, 1910, p. 185), but Buckman and Bather (1894, p. 427) have concluded that the sexual differences in ammonites, inferred by de Blainville D'Orbigny, Munier—Chalmas and Haug are "auxologic or bioplastic rather than sexual, being in some cases phylogerontic, in others merely ephebic or gerontic."

In regard to possible sexual differentiation of the shells in the Paleozoic forms, especially the early orthoceraconic nautiloids, we have not been able to find any suggestions in the literature at our disposal, which, however, is not complete except in *Barrande's Systéme Silurien* (v. 2, pt 1, p. 38 ff, 1877). There the fact of the wide differences in the relation of length of living chamber to the width at the base of the same in the mature stage of a number of species is shown in tables; this difference rising in some species, as Orthoceras culter, to a threefold length of the chamber in the longer forms. While Barrande would see in these wide differences of mature development of the living chamber only individual variations in size, (loc. cit. p. 39), we consider it very probable that they also denote the sexual difference in the size of the shell in these species.

Bibliography

Buckman & Bather. Natural Science, 1894, 4:427
Lankester, E. Ray. A Treatise on Zoology. Pt 5, Mollusca by Paul Pelseneer. London, 1906
Dean, Bashford. American Naturalist, 1901, 35:819
Woodward, S. P. A Manual of the Mollusca, London, 1910

3 On Some Cases of Reversion in Trilobites

Triarthrus spinosus was described by Billings (1857, p. 340) as characterized by a long spine that springs from the neck segment and a second one proceeding from the eighth segment of the thorax; and two long genal spines.

The writer has found this characteristic trilobite of the Canadian Gloucester shale among material from the upper Utica shale at Holland Patent, N. Y. These specimens exhibit a series of three successive spines on the axis of the eighth, ninth and tenth thoracic segments, and show further the genal spines to be inserted in a peculiar way forward of the genal angle, at a point about one-third the length of the head. Moreover the latter do not proceed backward but are curved outward at the base and slightly inward distally. Fine material of Triarthrus spinosus in the United States National Museum, indicates by the presence of spine bases that also the 11th to 13th thoracic segments bore spines. Finally, also some of the pleurae of the thorax seem to have been produced, at times, into long recurving spines; this is at least suggested by two such spines, found apparently attached to a fragment of a pleura, lying partly below a specimen.

Fig. 7

Fig. 8

Figs. 7, 8 Triarthrus spinosus Billings. Fig. 7: Billings's figure; fig. 8: laterally compressed specimen (x2), showing dorsal spines (from the Gloucester shale at Ottawa, Canada; original in U. S. National Museum).

The peculiar lateral spine of the free cheek, the series of long axial spines on the posterior segments, are characters not seen in Ordovician or later trilobites, but known of certain early Cambrian forms, especially of the family Mesonacidae. Also the long nuchal spine, on the occipital ring is very strongly developed in the Mesonacidae, but rarely seen in Ordovician and later trilobites.

Triarthrus is now the only Ordovician genus of the Cambrian family Olenidae (Olenus barely entering the Ordovician in Europe) and the last of that family which in its turn appears again as a further development of the Lower Cambrian family Mesonacidae. The characters here emphasized of T. spinosus and which distinguish this last of the Triarthri (the Gloucester shale being of

late and post-Utica age) from the other congeners make it thus strikingly similar to some of the earlier trilobites, as Elliptocephala asaphoides Emmons in the series of posterior axial spines; to Olenellus gilberti; O. fremonti, Eurycare etc. in the genal spines that, especially in the earlier growth stages wander forward along the margin of the free cheeks.

Inasmuch as these features are not known of trilobites in the Middle and Upper Cambrian and Lower and Middle Ordovician, it is proper to assume that in T. spinosus they are reversional and atavistic in character, using these terms in their popular meaning (see below).

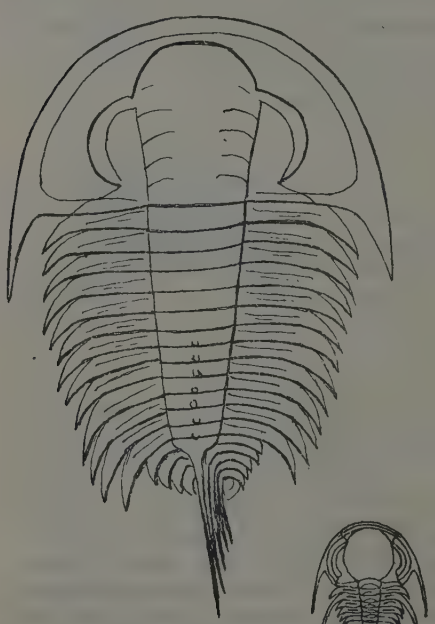


Fig. 9

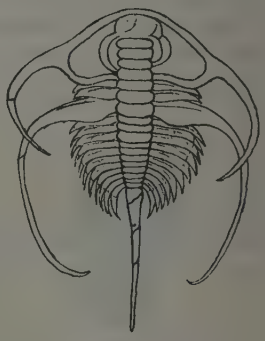


Fig. 10

Fig. 11

Fig. 12

Fig. 9 Elliptocephala asaphoides Emmons. Fig. 10 Olenellus fremonti Walcott. Fig. 11 O. gilberti Walcott. Fig. 12 Paradoxides inflatus Corda. (Figs. 9–11 after Walcott, fig. 12 after Barrande

Somewhat different characters suggesting atavistic tendencies have been observed by Doctor Clarke in Devonian trilobites (1913, p. 135). These consist in lateral spines on the cheeks in trilobites of the Phacops group: namely, Proboloides cuspidatus Clarke; and spinules on the basal margin of a cephalon of Dalmanites sp: this, however, being observed in but one case and not confirmed by other specimens. Doctor Clarke says regarding Proboloides cuspidatus:

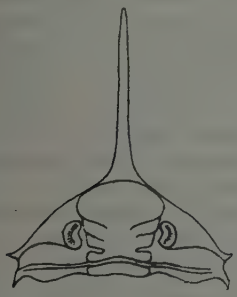


Fig. 13

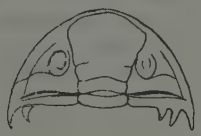


Fig. 14

Fig. 13: Proboloides cuspidatus Clarke; fig. 14 Dalmanites (Mesembria) sp.? (after Clarke).

"The elemental or reversional character of this entire group is expressed here by the singular and unparalleled reappearance of spines on the lateral margins of the cephalon at the outlet of the facial sutures and as these lie above the normal position of the spines at the genal angles, each cheek thus bears a pair of spines. This remarkable structure, the significance of which is more fully estimated in another place occurs in young and mature individuals alike so that it is in no wise an indication of uncompleted ontogeny but distinctly atavistic and due apparently to the reversional tendency which has accompanied or resulted from geographic isolation."

On page 22, op. cit., it is stated of Proboloides that it presents an unexampled retention, or reappearance, of primitive structures in its sutural spinules above the cheek angles, a structure not represented elsewhere above the Cambrian. Walcott (1916, p. 237) has more recently in his monograph of the Mesonacidae pointed out the reversion of this character of the Cambrian ancestors, as seen in a number of later trilobites. He states:

"The genal, intergenal and antero-lateral spines of the cephalon undoubtedly represent the pleural ends of segments that have been

fused together and greatly modified in the process. The genal spines persist in the adult of the Mesonacidae and often the intergenal spines, but only in a modified manner. The intergenal spines are seen in a later geological period in the adult Bronteus, where they might be considered as a reversion to a character of their Cambrian ancestors. Hydrocephalus appears to have an intergenal spine and in all of the Proparia (Beecher, 1897, p. 198) the "genal spine" is attached to the space within the facial sutures, and is in fact the prolongation of one of the fused segments of the cephalon, and corresponds in this respect to the intergenal spine of the Mesonacidae. Some of the species of the genus Agnostus also show spines that suggest the intergenal spine, notably A. granulatus Barrande and A. rex Barrande."

Assuming that, as the absence of connecting forms between the Cambrian and these Ordovician and Devonian trilobites suggests, the archaic characters of the later forms are not continuous with those of the Cambrian ancestors, then we would have either a reversion to an ancestral character of organs, never suppressed; or a reiterative development of organs that were apparently lost.

Biologists have of late years thrown considerable doubt on the occurrence of cases of "reversion," "atavism" and reiterative development. The law of "irreversibility of evolution" enunciated by Dollo in 1893 has been accepted by most biologists, although severely criticized by several; and Agnes Arber has lately drawn attention to a part of the broader principle recognized by Dollo, which she defines as the "law of loss." This indicates the "general rule that a structure or organ once lost in the course of phylogeny can never be regained; if the organism subsequently has occasion to replace it, it can not be reproduced, but must be constructed afresh in some different mode." Lull (1917, p. 572) would restrict the law of irreversibility of evolution to this impossibility of regaining a lost anatomical structure, defined as the "law of loss" by Arber.

An important qualification of this law is that it applies only to *actual* losses and not to *apparent* losses due to the interpolation of inhibiting factors (Arber, p. 27, footnote).

In analyzing the criticisms to which Dollo's law has been subjected on the part of botanists, notably by Errera who considered the law of irreversibility as disproved by the facts of "reversion" ("that is by cases in which a variation appears which is interpreted as an atavistic throw-back to a hypothetical ancestor, and in which some character since lost by the species makes a renewed appearance"); Mrs Arber found that the cases cited

possess "one common characteristic which seems to annul their significance as evidence of reversion," namely, "they all relate to meristic variations in which certain organs, of which at least one already exists, suffer an increase in number" (as p. e. the stamens).

According to Arber, the hypothesis of reversion has too often been employed by morphologists in a noncritical spirit, and "the only instances of genuine atavism of which we have any knowledge are those which consist in the synthesis by hybridization of some original form which has now become split into different races by loss of factors."

Another cause of "atavism" or "reversion" is not infrequently seen among fossils where a large number of species characterizing a certain horizon (see Grabau, 1913, p. 974) will be found "in which ancestral characters occur in the adult, thus recalling species of a lower geologic horizon." "This atavism or reversion of the species to ancestral characters may often be seen to be nothing more than an arrestation of development at an immature morphic stage, when the characters of the young are like those of the adult ancestor of earlier geologic horizons."

In looking at our case of reversion in Triarthrus spinosus in the light of the views just recorded, it is necessary to consider separately the forward carrying of the genal spine and the posterior series of long thoracic spines.

It is obvious from the development of Elliptocephala asaphoides and other Cambrian trilobites, that the earlier

Fig. 15

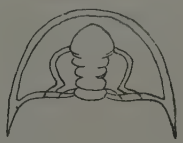


Fig. 17

Fig. 18

Fig. 19

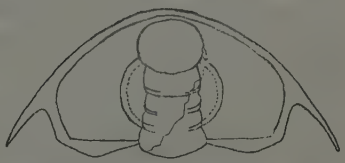


Fig. 20

Figs. 15–17 Elliptocephala asaphoides Emmons. Figs. 18–20 Olenellus fremonti Walcott. Growth-stages showing the forward position of the genal spines. (All after Walcott)

growth-stages are very apt to pass through a stage with farther forward-carried genal spines than are found in the mature stage (see text-figures, 15-17 and Walcott, 1886, pl. 20). And as in the case of Olenellus gilberti and O. fremonti closely related species with normal genal spines (O. gilberti) occur associated with those with laterally placed genal spines (O. fremonti) to such an extent that Walcott formerly (1886, p. 21) considered the latter as abnormal forms of the former; and the species fremonti possesses not only in the forward position of the genal spines but also in the greater expansion of the anterior glabella characters that suggest its retarded development as compared with O. gilberti. It might thus fall under the form of "reversion" cited by Grabau. It is likewise possible that the forward carrying of the genal spine in the ontogeny was inherited in those species of Triarthrus that possessed genal spines, from the Cambrian ancestors and retained even as long as late Ordovician time in the ontogeny. The apparent reversion in T. spinosus would then, as far as the genal spines are concerned, be a further development of an ontogenetic feature retained from the Cambrian ancestors. Possessing no growth-stages of either T. spinosus or earlier Triarthri with genal spines no definite conclusion can be reached as to this character.

It is different in regard to the series of long axial spines of the posterior thorax. In this case one might feel tempted to infer that meristic variation in form of increase has taken place pointing to the axial spine that is carried on the occipital ring in T. spinosus as an inheritance of this almost ever-present organ in the Cambrian trilobites. A comparison of Triarthrus spinosus with T. eatoni and becki, that possess a continuous series of mucros on the axis of the thorax, on the one hand, and with the associated T. glaber, that is completely smooth, leaves little doubt that in the axial spines of T. spinosus we have to do with organs that were never actually lost, as shown by the series of axial mucros of T. becki and eatoni, but had become more or less submerged (entirely in T. glaber) through the influence of inhibiting factors.

It is a peculiar fact that the axial line of spines, is so prominent in the Cambrian trilobites that the genera Albertella, Zacanthoides, Neolenus, Elliptocephala, Mesonacis, Callavia, Holmia, Wanneria, Paedeumias, Bathyuriscus, Dolichometopus, Ogygogopsis

and Asaphiscus contain species with rows of long axial spines or prominent mucros; while in the following Ordovician to Devonian periods this feature becomes suppressed to such an extent that, for example, in Barrande's wonderful array of Ordovician, Silurian and Devonian trilobites not a single form with this row of spines is found,[2] while Hall and Clarke (1888) found among the Devonian trilobites of New York but a single Dalmanites (Cryphaeus, namely, D. (Cryphaeus) boothi var. calliteles, one Phacops (P. cristata) and one Calymmene (C. platys) retaining faint tubercles on the axial line, and none, not even the highly spinose Acidaspidae exhibit rows of axial spines.

Now and then, however, a form will develop a single spine on one of the thoracic segments or the axis of the pygidium, as Lichas (Conolichas) eriopis Hall on the pygidium, and the strange Cyphaspis ceratophthalmus Goldfuss (see Richter, 1918, pl. 2, fig. 13) which has a single spine on the middle of the back. It is legitimate to consider these also not as new creations or reiterative developments, but as a local awakening of the dormant or latent axial spines of the Cambrian ancestors, reduced in the few Devonian forms cited above to the rudimentary vestiges represented by the small mucros. All these features, the axial series of spines or the single isolated spines, and the axial rows of mucros are thus the last traces of a character highly developed in the Cambrian ancestors and when thus appearing abruptly, as in T. spinosus or Cyphaspis ceratophthalmus partake of the character of atavisms or reversions, as popularly understood but in reality are revivals of latent characters that were never lost, and quite surely not cases of reiterative development.

The cause of this remarkable resuscitation of the axial spines, evidently once so useful to the Mesonacidae and other Cambrian trilobites, may well be sought in an adaptation or return to similar habits. Rud. Richter has lately shown in an interesting series of papers on the structure and life habits of trilobites, that many of the spinose appendages do not only serve for protection, or are merely spinose excrescences indicating gerontic condition as Beecher has urged, but had a very important function in allowing the creatures to float with little exertion in the water through the great

[2] Among the Proetidae Astycoryphe gracilis Barrande, however, is figured and described with a row of mucros by Richter (1919, p. 12 & 13) and A. senckenbergiana R. and E. Richter with mucros on the last four thoracic segments.

expansion of their surface and the increased friction in sinking. The single dorsal spine of Cyphaspis is, for example well comparable in function to the floating spine of the zoaea of crustaceans. Taking the case of the three species of Triarthrus, associated in the Gloucester shale; they should have had according to biologic principles different habits of life to avoid the disastrous competition among closely related forms; and it is very probable that the smooth T. glaber and eatoni beckiauct.) were more active bottom-swimmers, while the long-spined T. spinosus was more given to a floating habit in a little higher level of the water.

There remain the peculiar cases of reversions noted by Doctor Clarke in Devonian trilobites of South America and by Doctor Walcott in Bronteus, Hydrocephalus and the Proparia; and expressed in the intergenal spines at the base of the head and in the lateral spines of the free cheeks. It seems impossible to consider these cases of reversion as due to arrested development at an immature stage, for Beecher's studies of the protaspis-stages of various post-Cambrian genera have failed to reveal these archaic lateral and intergenal spines in the ontogenetic development of the later genera. Nor are they cases of meristic variation, especially not the intergenal spines. There would thus remain as possible explanation for them the assumption that they also present latent characters never actually lost but only submerged for longer or shorter time by the interpolation of inhibiting factors.

Bibliography

Billings, E. Geology of Canada, 1863, p. 202, fig. 199

Barrande, J. Sysème Silurian de la Bohême, v. 1, 1852, sup. 1872

Walcott, C. D. Second Contribution to the Studies of the Cambrian Faunas of North America. U. S. Geol. Survey; Bul. 30, 1886

Clarke, J. M. Fossei's Devonianos do Paraná. Monographias do Servico geologico e mineralogico do Brasil, 1913

Hall, J. & Clarke, J. M. Paleontology of New York. v. 7, 1888

Walcott, C. D. Olenellus and Other Genera of the Mesonacidae. Smiths. Misc. Coll. v. 53, p. 229. 1910

Grabau, A. W. Principles of Stratigraphy. New York, 1913

Walcott, C. D. Cambrian Geology and Paleontology. III. No. 5. Cambrian Trilobites. Smiths. Misc. Coll. v. 64, p. 301. 1916

Arber, A. On Atavism and the Law of Irreversibility. Amer. Jour. Sci., 48:27. 1919

Lull, R. L. Organic Evolution. New York, 1917

Richter, R. & E. Von unseren Trilobiten. II. 47. Ber. Senckenbergische Naturf. Gesellsch. 1918

Richter, R. & E. Der Proëtiden-Zweig Astycoryphe-Tropidocoryphe-Pteroparia. Senckenbergiana, 1:1. 1919

Richter, R. Vom Bau und Leben der Trilobiten. 1. Das Schwimmen. Senckenbergiana, Bd. 1. 1919, p. 213

4 On Color Bands in Orthoceras

Color markings on the shells of fossil mollusks and brachiopods have attracted the attention of authors from the early days of paleontologic investigation.

The American, and some European, publications describing color markings in Paleozoic fossils have been lately listed by Roundy (1914, p. 449); the European ones by R. Richter (1919, p. 94).[3] We see from these lists that zigzag color markings on a Carboniferous Pleurotomaria were described as early as 1836 by Philips in his Illustrations of the Geology of Yorkshire, and colored Terebratulas of the Triassic in 1845 by v. Alberti in Germany. Since that time a large number of cases of color markings have been described, especially of gastropods and brachiopods, and a large proportion of these from Paleozoic beds.

The oldest case on record of color marking seems to be that of the Holopea harpa from the Chazy of Valcour Island, N. Y., described by Raymond (1906, p. 101).

While most authors have simply described the color markings as fascinating traces of the original wealth of beauty and color of the shells that has been lost to us through their bleaching, some of the more recent publications, notably those of Kayser (1871), Steinman (1899), Deecke (1917), Oppenheim (1918) and Richter (1919), deal with the bearing of the mode of sedimentation and other factors on the retention of color markings, on possible conclusions from the coloring upon the facies and the origin of the coloring. Notice of their conclusions will be taken in another place.

We shall restrict ourselves here to the cases of color markings in certain Ordovician cephalopods and make our specimens the subject of a separate note mainly for the reason that their mode of coloration seems to bear directly on the question of their mode of life.

D'Archiac and Verneuil as long ago as 1842 described a specimen of Orthoceras angu.liferum from the Devonian at Paffrath, Germany, with "a beautiful chevron pattern." Marsh records (1869, p. 326) that in 1865 he procured a second specimen

[3] A complete list, including the numerous cases of mesozoic and tertiary shells with color markings has been given by R. B. Newton in 1907, a large list of color markings on fossil gastropods, brachiopods, pelecypods and one cephalopod was given by Kayser (1871, p. 265).

of the same species, while in Germany, with similar zigzag bands of the original color. They are associated there with gastropods (Natica subcostata), also bearing color markings. In the same note Marsh also states that in several instances he had found "distinct traces of the original color, arranged in delicate cancellated patterns" on "cephalopods from the Trenton limestone of New York, especially Endoceras proteiforme Hall." He further records "indications of color markings" in "Orthocerata from the Hudson and Niagara limestones of Illinois and Iowa."

Barrande has figured and described some fine examples of color markings in Paleozoic cephalopods, a fact that seems to have been entirely overlooked by the other authors. In volume 2 (pl. 108–244, 1866) of his Système Silurien de la Bohême, he figures on plate 155, figures 6 and 7, a spotted Cyrtoceras (C. maculosum); on plate 208, figure 21, a Cyrtoceras veteranum with sharp zigzag lines ("chevrons"), and on plate 240, figure 11, a Cyrtoceras decurio with beautiful zigzag transverse bands. All these are from étage E (Silurian) of Bohemia.

Blake (1882, p. 291) describes Orthoceras annulatum Sowerby from the Wenlock limestone with colored longitudinal bands.

Foerste, in a paper just published (1920, p. 212) has a note on "Orthoceras with vertical color bands." He states:

> In a specimen of an unknown species of Orthoceras found at the top of the Plattin limestone at Conn's Ford, vertical color banding is present. The specimen is 22 mm in width. The color bands equal or slightly exceed 1 mm in width and are 1 mm or slightly less apart. The color banding is a feature characteristic of the inner layers of the shell and is seen best where the surface of the shell has weathered away.
>
> Orthoceroid shells with vertical color bands are known also at other horizons. In the Lorraine formation in the river bed west of Weston, Ontario, vertical color bands occur in an Orthoceroid shell 22 mm wide, having a siphuncle with nearly spherical segments (Loxoceras?). About eight vertical color bands occur in a width of 5 mm, the width of the color bands and that of the intervals between being about the same.
>
> In similar species (Loxoceras?), from the Richmond formation at the Clay Cliffs on the eastern shore of Manitoulin island, the vertical bands are about 1 mm in width and are separated by intervals varying from 1 to 2 mm where the diameter of the shell equals 15 mm.

In Orthoceras trusitum Clark and Ruedemann, from the Guelph at Rochester, New York specimens occasionally show color banding. In the specimen represented by figure 2 on plate 13 of Memoir 5, New York State Museum, 1903, there are nine or ten vertical light brown bands in a width of 3 mm. In the specimen represented by figure 9 the structure usually accompanying color banding is present, but there is no distinctive color here. This structure consists in the space between the color bands being composed of a less dense and more readily weathering material than that forming the color bands.

In all cases of color banding observed by the writer the color banding consisted of various tints of brown.

The present writer has before him four splendidly preserved shells of a Geisonoceras from the Trenton limestone, that retain the color markings. Two of these were taken from a block of dark-gray, very fossiliferous limestone obtained at Watertown, N. Y., and the two others came from the very dark-gray, highly fossiliferous upper Trenton limestone at Middleville, N. Y. The former appear to retain even the original color. These specimens have been known to the writer for many years and they were kept with material to be used in a monograph of the cephalopods of the Trenton group.

This form, before us, has been described by Hall (1843, p. 205, 209) both as Orthoceras strigatum and Endoceras proteiforme var. tenuitexum. In the former case the surface has been weathered between the darker color bands leaving the latter as "the flexuous elevated longitudinal lines" which gave the form its name; in the latter the extremely delicate, cancellated surface sculpture is preserved and the color bands lost. The name O. strigatum would have the right of priority by virtue of its earlier description in Hall's work according to the strict application of the rules of priority, but in this case it would lead to the retention of a distinct misnomer, for the strigate or fluted character of the surface is but the result of weathering. We will therefore retain the better known name Geisonoceras tenuitextum (Hall) for the species.

The character now, which to us is the most important at present, is the presence of the color bands on one side of the conch only. In the specimen reproduced in text figure 21, which has a diameter of 16 mm, the color bands number 17, are .5 mm wide, brown and separated by interspaces, averaging .4 mm. Toward the side the bands become more widely separated, the last interspace being .9 mm wide, and then they end abruptly. The interspaces in the banded region are also decidedly darker (light brown) than in the bandless

region. In the second specimen (figure 22), from the same locality, which is 46 mm long, 9.4 mm wide at the wider end, and 5 mm at the narrower one, thirteen brown longitudinal bands can be seen on one half, while the other is entirely free from them. These lines, corresponding to the smaller size of the specimen, are but .3 mm wide at the thicker end and separated by interspaces .5 mm wide.

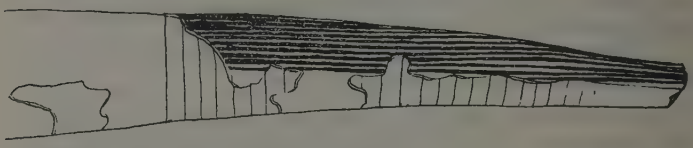


Fig. 21

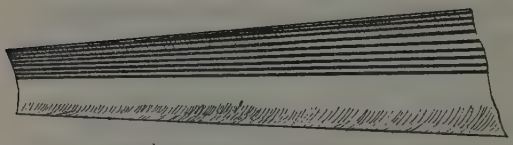


Fig. 22

Fig. 23

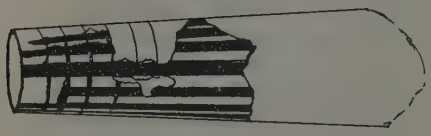


Fig. 24

Fig. 25

Figs. 21–25 Geisonoceras tenuitextum (Hall). Figs. 21 and 22 Lateral views of specimens (fig. 21 natural size, fig. 22x2), showing color bands on upper side. Fig. 23. Portion of specimen, showing the black mud filling shaded. x2. Fig. 24 Dorsal view of specimen, natural size. Fig. 25 Section of color-bands.

In the third specimen, from Middleville, seventeen color bands are counted on one side, while there are none on the other. These bands are 1 mm wide, where the conch is 19 mm wide, and separated by interspaces, .5 mm wide. The color of the bands is light brown at the narrower end, where the conch is filled with crystallized secondary limestone, and black in the other portion where the conch is filled

with the original black calcareous mud, forming the matrix. The fourth specimen shows only the banded side where ten color bands can be discerned.

These four specimens allow a number of observations, which bear partly on the nature of the color bands and partly on the habits of the creatures that made the shells.

The color bands were probably originally brown, as they appear now in three of the specimens. They are preserved only in that color where the conch remained free for a time from the dark mud that embedded the shells and became later filled by secondary white calcite. Thus in the first specimen, only a segment (the uppermost in the accidental position of the conch on the sea bottom) is filled with white calcite, the rest with black calcareous mud; the brown lines are seen on this segment, on the other part of the shell only as black smooth shadows. The second specimen is entirely filled with secondary calcite and retains the brown color lines in perfection. The third is only filled with crystallized white calcite in the narrower portion and the brown color lines are seen there. In the remainder they are dark brown to black.

The surface is, in all four specimens, provided with an extremely delicate surface sculpture, consisting of intersecting, nearly equal, transverse and longitudinal lines. These lines are so fine that they are only visible under a strong lens and about twenty are counted in 1 mm.

Not wishing to risk any of the specimens on account of the brittle nature of the crystallized calcite filling, we have not made any thin sections. On the natural section of the first specimen the brown band can be seen to extend about .1 mm into the interior of the shell as a dark-brown body, that thins toward the edges and extends to the surface. When weathering sets in, the lighter intervals between the colored bands begin to be dissolved first, the darker bands probably being protected by the insolubility of the pigment distributed there through the shell-substance. There result then the fluted forms which have been made the types of Orthoceras strigatum by Hall.

It is quite probable that this dark pigment belongs to the group of the melanin pigments which, according to Oppenheim (1918, p. 390), cause the dark coloring of numerous mollusk shells and being not dissolved by water, alcohol, ether and resisting even rather strong acids are little destructible. It is this utter insolubility in water which has secured for these melanin pigments the possibility of being preserved even through long geologic periods. Chitinous

or conchiolinous substances, with which some have compared these pigments, would have been destroyed long ago. Especially in the present case, where the etching of the shell has been able to destroy only the lighter bands, it would seem that melanin pigments that are characterized by their resistance to acids, must be present.

The greater resistance of the color bands to solution and weathering has, as stated before, been also observed by Foerste. The fact that also in all cases of color banding observed by Foerste, this banding consisted of various tints of brown, suggests that all these color bands consisted of melanin, perhaps in association with iron (see Oppenheim, op. cit. p. 391). Em. Kayser's experiments in the Devonian brachiopod Rhynchonella pugnus indicate that also there a melaninlike pigment in chemical combination with iron is in evidence.

The new and important feature in the Trenton limestone specimens before us is the fact that the color bands are present on one side of the conch only, the other side having been entirely white. We see in this phenomenon direct evidence that the species in question, Geisonoceras tenuitextum, was given either to crawling upon the bottom of the sea, or to swimming in a horizontal position; either of which habits would develop a differential coloring on the dorsal and ventral sides, the former assuming a darker, the latter a lighter color. It seems improbable that the long and straight cones could have been carried horizontally in swimming, especially as these cephalopods must be assumed to have, like all their recent descendants, swum backward by the expulsion of water from the forwardly directed funnel. The often delicate shells could not have stood the shock of frequent impacts incidental to such mode of propulsion, and the prevailing preservation of the acute apex of the conchs militates against the view that such impacts could actually have occurred at frequent intervals. It is therefore more probable that the conchs, buoyed up by gas in the air chambers, were lightly dragged over the soft mud of the bottom, by the probably sluggish animals.

There are several other observations that support this conclusion. The most important is that the conchs on closer inspection turn out not to be regular cones, but to be slightly curved so that the side with color bands (dorsal side) is slightly convex, while the other is straight or even a little concave. This feature, distinctly observable by holding a ruler against any part of the dorsal or ventral side, is too regular to be due to *postmortem* compression or fracturing.

In the cross-sections of the conchs, both the dorsal and ventral sides appear a little flatter or less curved than the lateral sides. This, however, may be due to later compression.

Another observation that to us seems to indicate a crawling habit of this species has been made in specimens found in the Utica shale at Holland Patent. These specimens are overgrown with a delicate creeping bryozoan, Spatiopora lineata compacta nov. The zoaria of this bryozoan begin to grow near the apex and then regrow forward toward the aperture and on one side of the conch only. They would, of course, have also grown on one side only, if they had spread over the conch while, after the death of the creature, it was resting on and partly imbedded in the bottom mud. It is, then, inexplicable why they should have grown forward as a rule, upon the conchs; a fact that clearly suggests that they attached themselves to the living and still growing shells and grew with the latter. In that case, the fact that the bryozoan shunned the underside would also indicate that this was a true ventral side in the movements of the animals, and that these latter were upon the bottom.

Dr Rudolf Richter, in Frankfort a/M who has lately (1919) published an excellent study of the coloring of fossil brachiopods has upon my informing him of my find, kindly pointed out to me (in letter of May 14, 1920) some questions that were raised in a discussion of my observation by his colleagues and that are liable to be raised also by others and therefore may be answered here. These are:

1 Is the siphuncle somewhat excentric in that species; and if so, is the colored part of the shell oriented toward this excentricity of the sipuncle? The siphuncle is visible only at the narrow end of the second specimen and there is central in position.

2 Can the loss of color on the single shell not have come about *postmortem?* And then on the exposed side only, which was the upper at the entombment of the shell, while the side lying in the mud favored the preservation of the colors as much as in many German ceratites the longer preservation of the conch on the underside (cf. Phillippi und Riedel: Beitr. z. Pal. u. Strat. d. Ceratiten; Jahrb. Preuss. geol. Landesanstalt 1916, Bd. 37, Teil 1, Heft. 1); or like the mummy of Trachodon has preserved its skin only on the (presumed) underside?

Dr Richter adds in his letter that my observation of the wider spacing of the bands toward the lateral sides indicates a primary differentiation in the coloring of both sides of the conch. Also the

fact that all three specimens which show both sides equally exhibit the banded upper and the white underside speaks for an actual color differentiation. Still more so does the fact that in specimens 1 and 2 the fine surface sculpture is equally well preserved on both the upper and under sides, thereby refuting the possibility of a stronger weathering of the uncolored side by temporary *postmortem* exposure. In specimen 3, where weathering and etching of the white intervals between the color bands has set in, both these and the underside lack the fine surface sculpture through secondary processes. Specimen 1 shows directly by the narrow segment (see text figure 23) with secondary crystallized calcite filling, which side happened to be the uppermost during entombment. This side which alone preserves the original brown color tint of the color bands belongs half to the dorsal and half to the ventral side. This shell came hence to rest on its lateral side during the entombment and it is the upper or exposed side that preserves the color banding most completely.

3 Would not the shell when ground near the oldest and most sensitive point, the apex, show traces of wear? The specimens with color banding at present available do not retain the apex. Specimen 2, which retains the youngest portion of these shells, is fractured still 45 mm from the apex. At the point of fracture, however, where it is but 5 mm wide, it retains the fine surface sculpture on all sides in the most perfect manner.

We thus see that the further facts brought out by the questions raised, rather help to corroborate the conclusion of the primary differentiation of the color banding on the ventral and dorsal sides of Geisonoceras tenuistriatum.

It is quite probable that also other species of Orthoceras with color banding possessed this only on one side. This is, at least, suggested by the specimen of Orthoceras trusitum Clarke and Ruedemann, from the Guelph limestone at Rochester and now in the New York State Museum, mentioned op. cit. by Doctor Foerste. In this the extremely narrow and crowded brown lines (nine to ten in a width of 3 mm) are also seen only on one side. They are, however, also there preserved only in certain patches and thus might well have been destroyed on the remaining parts of the surface. The same is true in regard to the other specimens among Clarke & Ruedemann's types which exhibit traces of color bands. Of these that of plate 13, figure 9, retains the fluting resulting from the weathering of the interspaces of the color bands, as far as the brittle specimen could be worked out, also only on one side. The type of the specimen of plate 12, figure 4, has on account of the longitudinal

color lines been referred to Kionoceras darwini (Billings) by the authors, but since these lines are also but brown color lines and the shell is smooth, it should more properly be identified with Orthoceras trusitum. Also this specimen seems to possess the brown color bands on one side only.

The zigzag markings of the Bohemian species of Cyrtoceras mentioned above as well as the beautifully scalloped and wavy color bands which Barrande has so well figured of Crytoceras parvulum (pl. 481, figs. 1–15), C. zebra (ibid. figs. 16–20); C. cyathus (ibid. figs. 21–24), C. parvulum (pl. 504, figs. 1–45) etc. pass entirely around the shell. These transverse color bands thereby contrast with the longitudinal color markings of Orthoceras here described.

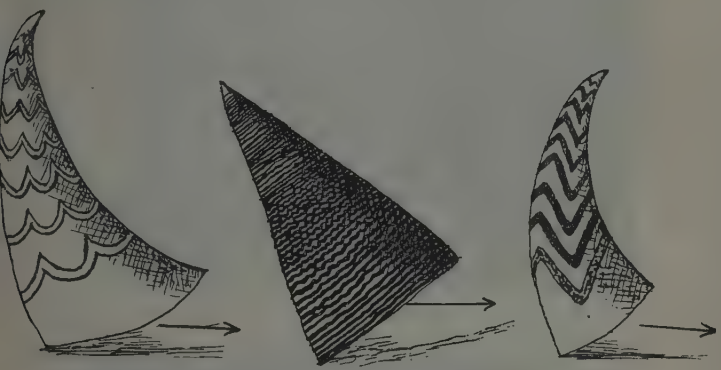


Fig. 26 Fig. 27 Fig. 28

Fig. 26 Cyrtoceras Zebra Barrande; fig. 27 C. parvulum Barr; fig 28 C. decurio Barr. (All after Barrande)

Likewise, do all the species of Cyrtoceras here cited, strongly contrast, by their breviconic and curved shells with wide open apertures with the long, slender, fairly orthoceraconic shells with longitudinal markings.

It is quite obvious that both color markings and form of conch are in both groups of shells in perfect harmony with their mode of life, in Orthoceras with a crawling habit, in which the conch is dragged behind; in the breviconic species of Cyrtoceras with a crawling habit in which the shell is carried obliquely or fairly upright, and as suggested by the position of the hyponomic sinus on the convex side, with the apex pointing forward.

The differentiation between dorsal and ventral color marking is lost in the latter forms, both sides being equally exposed to light and sight.

Bibliography

1836 **Phillips, John.** Illustrations of Geology of Yorkshire, v. 2, p. 226, pl. 15, fig. 2

1842 **M. D'Archiac & Verneuil.** Trans. Geol. Soc. London (2) v. 1, p. 346, pl. 27, fig. 6

1843 **Hall, J.** Paleontology of New York, v. 1.

1866 **Barrande, J.** Système Silurien de la Bohême, v. 2, pl. 155, figs. 6, 7; pl. 208, fig. 21; pl. 240, fig. 11

1869 **Marsh, O. C.** On the Preservation of Color in Fossils from Palaeozoic Formations. Proc. Amer. Assn. Adv. Sci. 17th meeting, p. 325

1871 **Kayser, E.** Notiz über Rhynchonella pugnus mit Farbenspuren aus don Mollusken. Ber. d. naturf. Ges. zu Freiburg. i. B. v. 11, p, 40

1882 **Blake, T. F.** Monograph of the British Fossil Cephalopoda, pt 1, p. 291

1889 **Steinmann, G.** Ueber die Bildungsweise des dunklen Pigments bei den Mollusken. Ber. d. naturf. Ges. zu Freiburg. i. B. v. 11, p. 40

1906 **Raymond, P. E.** An Ordovician Gastropod Retaining Color Markings. The Nautilus. v. 19:101

1907 **Newton, R. B.** Relics of Coloration in Fossil Shells. Proc. Malacozool. Soc. of London, 7:280

1912 **Girty, G. H.** Notice of a Mississippian Gastropod retaining Coloration. Amer. Jour. Sci., 34:339

1914 **Roundy, P. V.** Original Color Markings of Two Species of Carboniferous Gastropods. Amer. Jour. Sci., 38:446

1918 **Oppenheim, B.** Ueber die Erhaltung der Färbung bei fossilen Molluskenschalen. Centralbl. f. Min., Geol. & Pal. Jahrg. 1918. p. 368

1919 **Richter, R.** Zur Färbung fossiler Brachiopoden. Senckenbergiana v. 1. No. 3, p. 83, 172

1920 **Foerste, F.** The Kimmswick and Plattin limestones of Northeastern Missouri. Denison Univ. Bul., J. of the Scientific Laborat., 19:175

5 A new Eurypterid from the Devonian of New York

The Devonian of New York has thus far afforded but extremely scanty remains of eurypterids, and these are referable to two species, apparently all of the genus Stylonurus. These are the Portage form Stylonurus (?) wrightianus (Dawson), represented only by a leg joint, and the Catskill form Stylonurus (Ctenopterus) excelsior Hall. If we add to this the other Catskill species S. beecheri (Hall), from Warren, Pa., known only from an abdomen and leg and the Pterygotus atlanticus Clarke and Ruedemann, from the Devonian of New Brunswick, based on some fragments of appendages, the list of the eurypterid

remains in our Devonian is completed (excluding two very doubtful eurypterids from New Brunswick). Any find of eurypterid remains is therefore of great interest and worth recording.

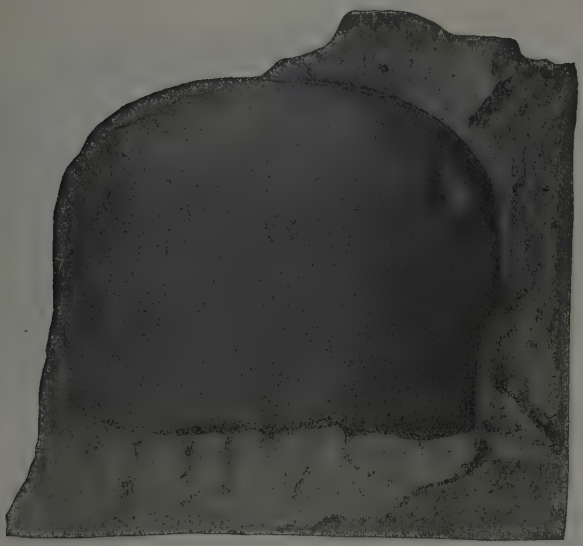


Fig. 29

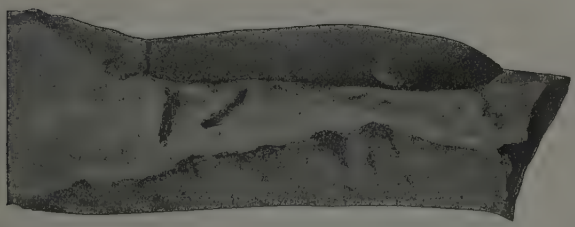


Fig. 30

Figs. 29, 30 Pterygotus inexpectans nov. Dorsal and lateral views of type. Natural size.

The subject of this note is a carapace of a Pterygotus found by the writer while collecting fern-trees in the Oneonta beds at Gilboa, N. Y., in association with Messrs C. A. Hartnagel and H. P. Woodward.

Pterygotus inexpectans nov.

Description. Cephalothorax trapezoidal in general outline, about one-ninth wider than long; the lateral margins slightly sigmoidal, being concave in the posterior, and convex in the anterior half, producing a slightly forwardly expanding shape of the carapace. Anterior margin well rounded, and posterior margin nearly transverse, slightly bent forward at the subrectangular postero-lateral angles. The surface seems to have been flat in the posterior half and gently convex in the anterior, with a fairly abrupt decline at the frontal margin. The lateral eyes are very prominent, but relatively small (a little more than one-fifth the length of the carapace), subelliptic in outline and situated in the antero-lateral corner of the carapace. The ocelli are large and distinct, and situated on a line connecting the posterior extremities of the compound or lateral eyes; or about two-fifths of the length of the carapace from the anterior margin. The marginal thickening is well developed, about 1 mm wide. The surface shows traces of low tuberculation.

Measurements. Greatest width (behind compound eyes) 66 mm; basal width 62 mm; length 53 mm; greatest height 8 mm. Length of compound eyes 10.5 mm; width of same 6 mm.

Horizon and locality. Upper tree-fern beds in Oneonta sandstone at Gilboa, Schoharie county, N. Y.

Remarks. This is the first Pterygotus found in the Devonian of New York. Compared with its American Silurian congeners, especially P. buffaloensis and macrophthalmus, it is distinguished by the relatively small size of the compound eyes and the sigmoidal curve of the lateral margins, or the forward expansion of the carapace; features in which it shows a certain approach to the Old Red sandstone forms of Scotland, and particularly to the remarkable Slimonia acuminata, which not only possesses like small, but prominent lateral eyes, but also a slight lateral expansion of the carapace in the anterior portion and a like strongly developed thickening of the margin.

Both the discovery of the carapace and leg parts of the gigantic Stylonurus excelsior near Andes in the Catskill beds, and the finding of this Pterygotus which, judging from the carapace in hand, also reached a size of a foot and a half, in the underlying Oneonta beds, suggest that some day there may be obtained in the American equivalent of the British Old Red sandstone, in the Catskills of New York, an eurypterid fauna as striking and important as that made known by Salter and Woodward from Great Britain.

Note. Since writing the above two more remains of eurypterids have been obtained in the Devonian plant-beds; one the cephalothorax reproduced in text figure 31, and the other the small specimen seen in text figure 32.

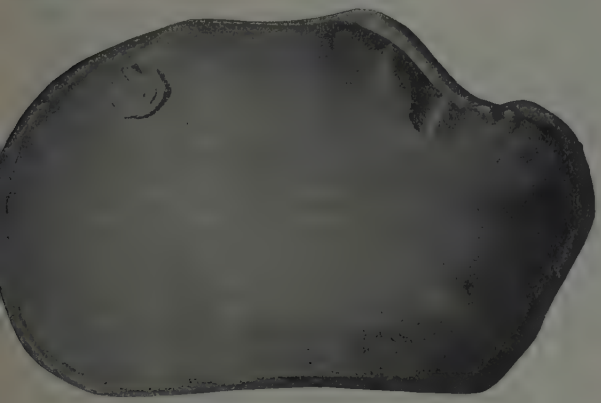


Fig. 31

Fig. 32

Figs. 31, 32 Pterygotus cf. inexpectans nov. Natural size.

The larger specimen was collected in the Oneonta sandstone at the Manorkill near Gilboa, below the horizon of the tree trunks. It is preserved in a sandstone that contains numerous brachiopod shells, mostly Spirifers, of the disjunctus type, and a new Hydnoceras. The smaller is embedded in a mud shale full of plant remains and recorded as having been collected in the Catskill beds near Walton, N. Y.

The cephalothorax apparently belongs also to the species here described, but is strongly compressed from the front backward, as is indicated by the folds paralleling the posterior margin and by the bulging out of the cheeks, especially the left one. A restoration of the shield to its original form would furnish an outline fairly corresponding to that of the type specimen. The compound eye was preserved on the left side in the antero-lateral corner, but partly lost in working out the specimen. The surface is slightly weathered and rough on the right side which had been exposed for some time and fairly smooth on the left which was protected in the matrix and chiseled out. The specimen is mainly interesting on account of its larger size and its association with a distinctly marine fauna.

The posterior portion of a smooth cephalothorax that may very well have belonged to the same species was also found in the plant beds that have afforded the smaller specimen. This small individual may also belong to the same species. At least the outline of the cephalothorax and of the postabdomen, as well as the submarginal position of the supposed compound eye, suggest its reference to Pterygotus, although the specimen is not sufficiently perfect to give conclusive evidence as to either its generic relation or relative age. The cephalothorax is narrower than in the adult age, but possibly so to some degree by lateral compression. The preabdomen retains only one or two segments, the first of which is pushed under the cephalothorax, and the postabdomen has been pushed forward into the preabdomen, giving the body an altogether too short outline. Traces of relatively weak and narrow swimming legs, such as are possessed by Pterygotus are seen close to the sides of the body.

6 Preservation of Alimentary Canal in an Eurypterid

A small series of eurypterids from the Silurian waterlime at Kokomo, Ind., bought some years ago from Ward's Natural Science Establishment, contains a specimen of Eusarcus newlini Claypole, that is worth noting for two reasons; first, it is a younger individual than has hitherto been observed and exhibits certain adolescent features; and second, it retains the alimentary canal; to the writer's knowledge, not before observed, or described, at least, in any eurypterid.

The specimen is but 142 mm long, or one-fourth the size of the large specimen figured by Clarke and Ruedemann (*The Eurypterida of New York*, 1912, on pl. 39). In its relative dimensions it corroborates the view expressed before (ibid., p. 252) that the mature individuals had a more robust and less agile appearance; for this young individual is distinguished from the supposedly mature form by a relatively more slender body, a more elongate carapace, less broadly expanded preabdomen and relatively longer postabdomen. The legs are distinctly more slender, though not relatively longer. The eyes which are placed terminally in front, are more prominent than in the later stages though not any more relatively larger.

The alimentary canal is traceable through the greater part of its length. It is seen from the dorsal side, beginning in the middle of the carapace with an expanded portion 8 mm long and 5 mm wide and extends thither as a perfectly straight tube, with a nearly uniform width of 3.5 mm to within 3 mm of the posterior edge of the last postabdominal segment, where it abruptly disappears.

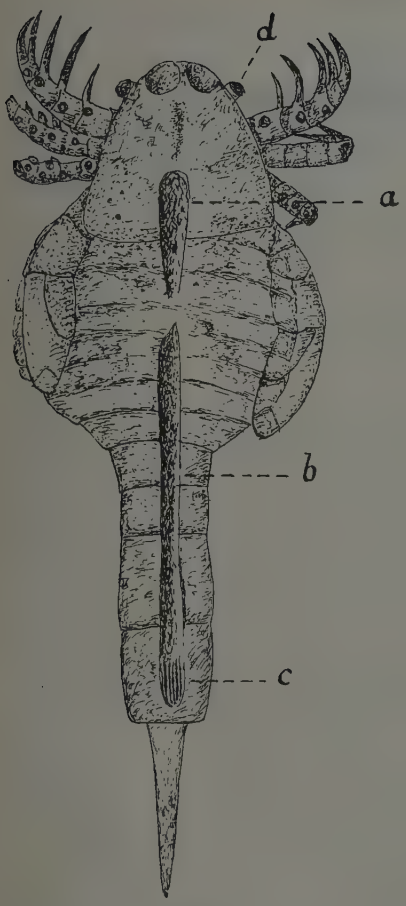


Fig. 33

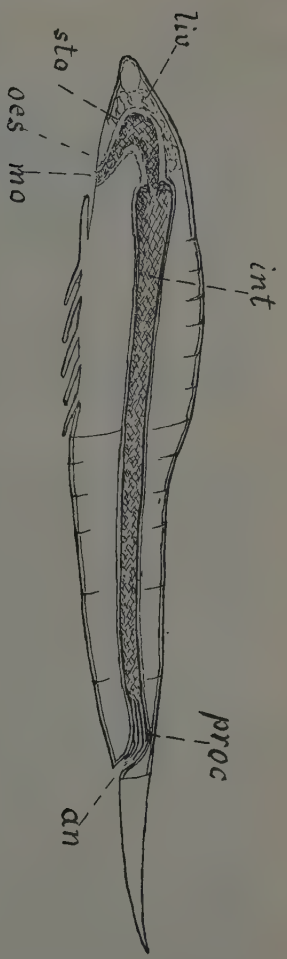


Fig. 34

Figs. 33, 34. Eusarcus newlini Claypole. Fig. 33 Specimen retaining alimentary canal: a expanded anterior portion of mesenteron, b mesenteron, c proctodaeum or rectum. Natural size. Fig. 34 Diagrammatic view of median longitudinal section showing alimentary canal. *Mo.* mouth, *oes.* oesophagus, *sto* stomach, *liv* liver, *in* intestine, *proc* proctodaeum, *an* annus.

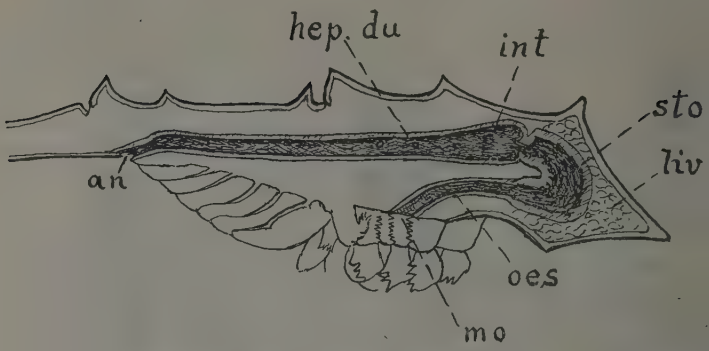


Fig. 35 Diagrammatic view of median longitudinal section of *Limulus*. Lettering as above. (After Parker and Haswell.)

A comparison of this intestine with that of Limulus (see text figure 35) shows that the two are identical in shape and position; the exposed part of that of Eusarcus newlini beginning with the slightly expanded anterior portion of the mesenteron behind the stomach (proventriculus). The latter was, undoubtedly, as in Limulus, situated at the anterior extremity of the cephalothorax and extended downward, being more or less bent upon itself, leading anteriorly into a suctorial pharynx and the oesophagus, and being surrounded by a large gland, the so-called "liver."

The intestine or mesenteron itself was a straight tube, relatively much longer than in the more compact Limulus.

The posterior portion exhibits distinct longitudinal folds and possessed thus a like structure as the proctodaeum or rectum of Limulus.[4]

It appears that the proctodaeum was as in other eurypterids, first bent upward, producing in some, as in Pterygotus, a crest by impinging against the dorsal side of the ultimate segment, and then sharply downward; the anus, which was on the ventral side, not being exposed in the specimen.

The preservation of the intestine is proof that the specimen was not originally a molted skin, but a whole individual that became entombed at the bottom of the sea; and the excellent preservation and undisturbed position of the appendages indicate that the creature

[4] See the elaborate "Studies of Limulus" by Patten and Redenbaugh. (Journal of Morphology, v. 60, 1900.)

had lived where it was buried, in the Silurian sea which deposited the Kokomo limestone at approximately Bertie time, and was hardly carried any great distance out to sea, as some would have us believe.

7 Note on Caryocaris Salter

The genus Caryocaris was erected by Salter (1863, p. 135) for a small crustacean from the Skiddaw slate series of Wales. His monotype C. wrightii is described as follows: "A long, pod-shaped, bivalved carapace (with distinct hinge-pits), rounded anteriorly, subtruncate behind, and with the back and front subparallel. The surface is smooth, or with only oblique wrinkles near the margins, but with no parallel lines of sculpture. Body? Telson and appendages?" The little crustacean is described with the Skiddaw graptolites and stated to occur "everywhere in the Skiddaw slate district."

In 1876 a second species was described by Hicks as C. marrii (1876, p. 138). This form, which is associated with the genotype, is said to be smaller, being both shorter and narrower.

The genus is noted again in the first part of the British Palaeozoic Phyllopods by Jones and Woodward (1888, p. 5), where in the table of the known genera of fossil Phyllocarida, it is placed near Ceratiocaris and the carapace characterized as "podlike; elongate, narrow, smooth," and the genus as occurring in the Arenig and Lingula flags.

In the second part of this important monograph, both C. wrightii and C. marrii are elaborately described and figured, and a third form, which had been made known by M'Coy as Hymenocaris salteri from the graptolite shales of Australia is also, with doubt, referred to Caryocaris, as Salter had done already in 1863 when he saw the specimen.

Of all these species only the carapaces are described. These alone were known to Salter who, however, in a restoration suggested "a strong, tapering telson (or last body-segment), carrying a sharply lanceolate style and stylet" (see text figure 36). Professor Marr found in association with Caryocaris some small slender spines or pointed styles which are longer than Salter's ideal figure (Jones and Woodward, p. 89) and Professor Malaise loaned the authors of the monograph a specimen from the graptolite shale at Gemboux, Belgium, that shows "three definite sharp daggerlike stylets as the cercopods of this genus" (see text figure 37).

Fig. 36

Fig. 37

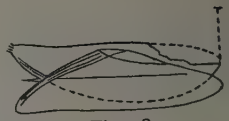


Fig. 38

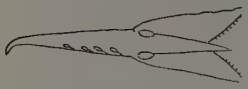


Fig. 39

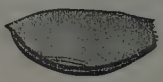


Fig. 40

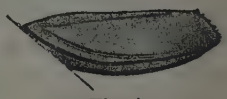


Fig. 41

Fig. 42

Fig. 43

Fig. 44

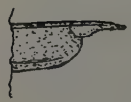


Fig. 45

Fig. 46

Fig. 47

Fig. 48

Fig. 49

Fig. 50

Fig. 51

Fig. 36 Salter's figure of Caryocaris wrightii. Fig. 37 Specimen figured by Jones and Woodward. Fig. 38 C. curvilatus Gurley (Gurley's figure). Fig. 39 Gurley's figure of C. wrightii. Figs. 40–44 Carapaces and telsons of C. curvilatus (Ruedemann's figures, 1908). Figs. 45–51 New figures of C. curvilatus. Fig. 45 Anterior carapace with rostrum, x3. Fig. 46 Carapace with abdomen. Nat. size. Fig. 47 Posterior fringe of carapace, x3. Figs. 48, 49 Abdomina, x3. Fig. 50 Telson of large specimen, x3. Fig. 51 Restoration in natural size.

In 1896 (p. 85) Gurley described three species of Caryocaris from America, namely, C. wrightii, C. oblongus and C. curvilatus, the first from the Beekmantown shale in Nevada, the second from the same shale in Quebec, and the third from both regions. He referred, however, the genus to the graptolites, from its supposed resemblance to Dawsonia, claiming (ibid., p. 86) that Lapworth agreed with him in this view. Gurley held that what hitherto had been described as Caryocaris were only appendages, and that the complete body consists of "two symmetrically paired lateral appendages attached to the distal end of a single median proximal portion on which thecae could perhaps be traced" (see text figure 39). This view was rejected in a brief note by Wiltshire, Woodward and Jones the year after it had been advanced (1897, p. 4).

In the first volume of the Graptolites of New York, (1904, p. 737) the present writer has doubtfully referred a form from the Deep kill shale of New York to Caryocaris curvilatus but having only the podlike bodies before him he did not care to select between the conflicting opinions.

In the preparation of the second volume, the writer had an opportunity of studying Gurley's type material from the Piñon range in Nevada and it was then recognized that this material contained partial abdomina with the telson consisting of a style and two flanking cercopods, and that these abdomina had been construed by Gurley into winged graptolite rhabdosomes (see Ruedemann, 1908, p. 486). It may be mentioned here that on inspection of the preservation of the material, the similarity of the substance of both groups of fossils, and the frayed character of the margins of many specimens, due to the "plaiting" or imperfect cleavage of the shale and suggestive of graptolite thecae, readily enough explains the origin of Gurley's misconception about their nature.

While undoubtedly a crustacean, Caryocaris still remained an imperfectly known genus; as is indicated by Zittel's definition, retained in the last edition of Zittel–Eastman's textbook (1913, p. 751) which reads: "*Caryocaris, Salter.* Carapace smooth, subacute in front, thick. Abdomen unknown; caudal plate with three spines. Cambrian; Wales."

In a collection of Lower Ordovician graptolites from the Alaska-Yukon boundary sent to the writer by L. D. Burling of the Geological Survey of Canada for identification, a small number of specimens of Caryocaris were noted, one of which retains the abdomen in

place. This fact as well as the presence of other characters hitherto unknown have suggested this note, the material having been kindly presented to the New York State Museum by Mr Burling.

The shape of most of the individuals in both the American and British graptolite shales being more or less modified by pressure, it is somewhat hazardous to base specific differences on the outline of the carapace. The British authors, however, have separated a very narrow form as C. marrii from the broader wrightii. Of the three species distinguished by Gurley among the American forms, C. wrightii may be rejected on the ground that the author based this identification on telsons and a misconception of the structure; his C. oblongus, a Point Levis form, and said to be distinguished from the others by its "regularly oblong shape" is too imperfectly known to concern us here. His C. curvilatus, however, from the Beekmantown graptolite shale of Summit, Nevada, as based on his first figure (see text figure 38) appears to comprise the form before us from the Alaska-Yukon boundary. At any rate, the latter is not sufficiently different either in age or outline to warrant distinction in this place.

One of the bivalved carapaces (see text figure 46), 22 mm long, though not perfect in front, retains a short, rapidly tapering abdomen 6.5 mm long in which five segments can be distinguished, beyond the posterior extremity of the carapace, not counting the last segment which may represent the telson (the specimen is not complete at this end either). Another detached abdomen (see text figure 49) exhibits five segments and a fragment of a sixth, besides the telson spine, so that it may be said with reasonable security that the abdomen of Caryocaris consisted of six or more segments. The caudal appendages (see text figure 50) consist of a broadly acute style (telson) that is flanked by two somewhat leaflike expanded or lanceolate stylets or cercopods. The inner edge of these were seen in the Nevada material (see text figure 44) to be provided with fine setae.

The carapace was considered by Salter as being broader posteriorly, Jones and Woodward (op. cit., p. 90) preferred, however, "to regard the broader and prow-shaped end as the front." Our material fully supports their contention.

The posterior margin appears often provided with a fine ciliated fringe. Jones and Woodward observed this, but owing to the "plaiting" or imperfect cleavage of the compressed flagstone attributed this feature to the incidents of preservation, stating that owing to this cleavage, "occasionally, when they [the valves] lie

parallel with the superinduced grain of the schist, their ends are frayed out or 'plaited' into a mere fringe." The writer (op. cit., 1908, p. 488) following suite, also attributed the "row of cilialike processes" observed by both Gurley and himself at the posterior margin of the carapaces of C. curvilatus (see text figure 47) to this "plaiting." The Alaska–Yukon material, however, which is not obscured by an imperfect cleavage leaves no doubt that the posterior margin of the carapace was indeed furnished with a fine comb of uniform bristles or teeth corresponding to the "fringe" observed in certain species of Ceratiocaris, as p. e. C. (Limnocaris) salina Ruedemann (N. Y. State Museum Bul. 189, pl. 33, fig. 4, 5).

Gurley's type specimen of C. curvilatus exhibits (see text figure 38) a straight line projecting between the two partly overlapping valves, that remained unexplained by Gurley, but was suggested by the writer (op. cit., 1908, p. 488, footnote) to be possibly of the nature of a rostrum. The specimen, here reproduced in text figure 45 exhibits the true rostrum. It shows a distinct plate in position, that is very sharply acute in front and rounded ovate posteriorly and that can not be otherwise considered but as a rostrum. The straight thick line along the dorsal margin may be only a reinforced edge rather than a median plate.

No distinct eye-tubercles could be made out in the material at our disposal.

It may finally be noted that Zittel's Handbuch and Zittel–Eastman's textbook cite Caryocaris as a Cambrian genus according to the former correlation of the Arenig flags. The Skiddaw graptolite shales in Great Britain are, however, now known to be of Lower Ordovician age and to correspond to the graptolite beds in Nevada, Levis at Quebec and the Alaska–Yukon boundary which have afforded the American specimens of Caryocaris. It is, hence, safe to define Caryocaris properly as a Lower Ordovician or Canadian genus, instead of a Cambrian one; as indeed has already been done by Bassler in his invaluable Bibliographic Index.

The form of the abdomen, telson and rostrum here described, leave no doubt that Caryocaris is closely related and very similar to the genus Ceratiocaris, that becomes so prominent in the later Ordovician and Silurian periods. It still differs from the latter in the shape of the carapace which is broader anteriorly and in the absence of any linear surface sculpture.

Bibliography

Salter, J. W. Note on the Skiddaw Slate Fossils. Quar. Jour. Geol. Soc., 19:135. 1863

Hicks, H. Appendix to Marr, J. E. Fossiliferous Cambrian Shales near Caernarvon. Quar. Jour. Geol. Soc., 32:134. 1876

Jones, J. A. & Woodward, Henry. A Monograph of the British Phyllopoda Palaeontogr. Soc. 1888, 1892

Gurley, R. R. North American Graptolites. Jour. Geol., 4:63. 1896

Wiltshire, I.; Woodward, H.; Jones, T. R. The Fossil Phyllopods of the Palaeozoic Rocks. 13th Rep't of the Committee. Brit. Assn. Adv. Sci., Toronto, 1897

Ruedemann, R. Graptolites of New York, pt 1, N. Y. State Museum Memoir 7, 1904; pt 2, Mem. 11, 1908

Zittel, K. A. Handbuch der Palaeontologie, Bd. 2, 1881–85

Zittel-Eastman. Text-book of Palaeontologie, v. 1, 1913

Bassler, R. Bibliographic Index of American Ordovician and Silurian Fossils, v. 1, U. S. Nat. Mus. Bul. 82, 1915

8 Fauna of the Dolgeville Beds

Professor Cushing (see Miller, 1909, p. 21) has designated as Dolgeville shales the passage beds between the Trenton limestone and Utica shale in the Dolgeville region, 25 miles east of Utica. It has been pointed out by the writer (1912, p. 27, 28) that these beds, and we may add, the directly overlying black shale as far as the fall below Dolgeville, contain the fauna of the upper Canajoharie shale. There was no faunal list of the Dolgeville shale published at the time. Having had occasion in the meanwhile, in connection with the study of the Utica, to prepare a list of the Dolgeville fauna, we wish to embrace this opportunity to put the same on record, partly because it contains some very interesting elements that were not noticed in the other outcrops of Canajoharie shale, and partly because it represents the westernmost occurrence of the Canajoharie in New York.

There were obtained, by the writer, in these beds:

Teganium rauffi *Ruedemann* r
Climacograptus spiniferus *Ruedemann* r
C. typicalis *Hall*
Glossograptus quadrimucronatus postremus *Ruedemann* c
Lasiograptus (Thysanograptus) eucharis *Hall* cc
Chaunograptus gemmatus *Ruedemann* rr
Paleschara *sp.* r
Lingula curta *Hall* c
L. riciniformis *Hall* c
Leptobolus insignis *Hall* cc

Schizocrania filosa *Hall* r
Dalmanella *cf.* rogata *Sardeson* r
Conularia papillata *Hall* rr
C. gracilis *Hall*
Serpulites angustifolius (*Hall*) c
S. gracilis *Ruedemann*
Liospira cf. subtilistriata (*Hall*) r
Triarthrus becki *Green* c
Calymmene senaria *Conrad* c
Isotelus gigas *Dekay* r
Ulrichia bivertex (*Ulrich*) c
Primitiella unicornis (*Ulrich*) c
Primitia *sp.*
Aparchites minutissimus (*Hall*) c

While there are already present a considerable number of Utica forms, the fauna as a whole differs in aspect from the later lower Utica in the presence of such Canajoharie species as Climacograptus spiniferus, Ulrichia bivertex and Primitiella unicornis. In Conularia papillata, C. gracilis, Serpulites gracilis, Chaunograptus gemmatus, the horizon affords peculiar types possibly restricted to it.

9 Additions to the Snake Hill and Canajoharie Faunas

The Snake Hill shale of the Hudson River valley, of lower and middle Trenton age, has afforded a large and peculiar fauna, of which eighty-three species have been listed thus far (Ruedemann, 1912, p. 62, 63), many of them new to science. It seems worth while to record in this place additions to this fauna from the temporary exposures at North Albany and at Watervliet, a few miles north of Albany.

1 Dystactospongia radicosa nov.

Description. Sponge of medium size elongate, probably cylindrical and originally of massive structure. Paragasters small, widely apart on surface, surrounded by radiating and anostomosing furrows. The latter contain scattered depressions, apparently former apertures (postica), that in some places become so closely crowded as to constitute the furrows. The lower (?) or supposedly basal portion of the sponge shows concentric wrinkles, suggestive of the presence of an epithecal layer. Skeletal elements mostly destroyed, through solution and compression; those noticed apparently of a nature that would indicate a composition of tetraxons similarly as is found in aulucopoid Lithistidae.

Measurements. Length of type-specimen 73 mm; width 25 mm; diameter of radial systems of furrows 15 mm; width of paragasters 1 mm.

Horizon and locality. Black calcareous shale at Rockwell's, Isle La Motte, Vermont; of Trenton age and most probably referable to the Canajoharie shale.

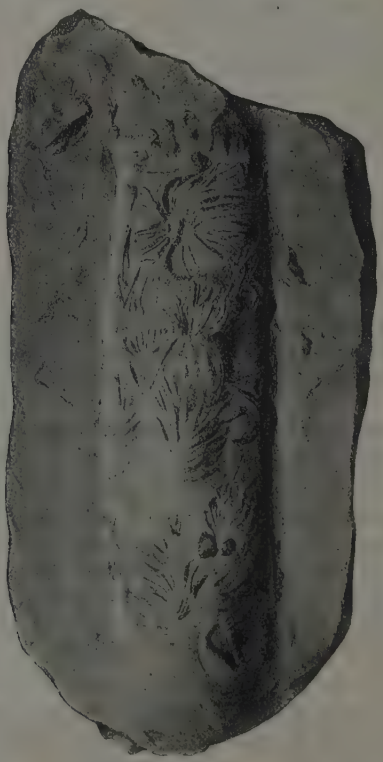


Fig. 52

Fig. 52 Dystactospongia radicosa nov. Natural size.

Remarks. The type specimen was collected by the late Prof. H. M. Seeley of Middleburg, Vt., and sent by him to the United States National Museum (no. 15242). The single striking feature of the imperfect fossil is the groups of radiating surface canals (aporrhysa), that surround the paragasters, of which three may be

counted in our specimen. The latter are, owing to the imperfection of the material through flattening of the specimen much obscured. The section of the specimen, seen along a fracture, is very flat lenticular, without a trace of a median line or layer, that might have resulted from the presence of a general cloaca, making the cylinder a hollow one.

We have referred this species to the genus Dystactospongia Miller, because it has in common with that genus, as represented by the genotype D. insolens, the system of paragasters with radiating furrows. We are well aware of the fact that the skeletal system of that genus is still unknown and that for that reason it has but little standing in modern spongiology and, moreover, may finally turn out to have an entirely different skeletal structure than our form. Nevertheless, as an American author on sponges has aptly remarked, even though the structure of these sponges is as yet conjectural, they need names before all so that they may be noticed and handled by collectors and in the literature. We may leave then to time the production of better specimens, and the elaboration of their skeletal structure.

2 Trematis punctostriata Hall. var. minor nov.

This well-characterized species, hitherto known only from the middle Trenton (Hermitage) of Tennessee and Kentucky has been found in numerous, though mostly fragmentary and small, speci-

Fig. 53

Fig. 54

Fig. 55

Fig. 56

Fig. 57

Figs. 53–57 Trematis punctostostriata Hall var. minor nov. Fig. 53 Type x3. Fig. 54 Cotype x2. Fig. 55 Enlargement of sculpture. Fig. 56 Pedicle-valve, x3. Fig. 57 Trematis terminalis (Emmons) x2.

mens in the Snake Hill shale. These exhibit the characteristic sculpture of the species, consisting of relatively distant pits placed in radiating grooves. The largest specimens, attaining a length and width of about 8 mm, agree in outline with the typical material from Clifton, Tenn., while the smaller individuals are narrower and with more prominent beaks, suggesting in this regard the later T. umbonata Ulrich. Considering this difference and that in size, it is seen that the Snake Hill form, may properly be considered as a smaller variety. It is evident that the whole Snake Hill fauna is largely a microfauna due to the unfavorable shale facies, and that one could recognize a considerable number of forms as small varieties of species occurring in larger individuals in the limestone facies of the Trenton.

Trematis punctostriata was originally described by Hall in the 23d Report, New York State Cabinet of Natural History, 1873, and has been fully figured by Hall and Clarke in the Palaeontology of New York, volume VIII, plate IVG. It has more recently been discussed by Foerste (1910, p. 37) who describes the shell as large, attaining a width of 30 mm; being nearly circular in outline; the width a little greater than the length. The brachial valve is, in our specimens as in the typical material, "moderately convex, the convexity increasing toward the beak." The radiating rows of pits are closer together, and the pits larger, in the anterior half of the shell, according to Foerste, eight to eleven rows occupying a width of 2 millimeters. We have counted eleven rows, on fragments, of the anterior portion, within the mentioned space. "Posteriorly, especially along the umbonal part of the shell, the radiating rows are more distant, and appear like narrow grooves crossing an otherwise comparatively flat surface." These grooves near the edges of the posterior portion are well seen in the figures here given of the variety minor.

3 Trematis terminalis (Emmons)

Another Trematis of the Snake Hill shale, north of Albany, deserving mention in this place, is T. terminalis Emmons. This form, formerly known only from the Trenton limestone in New York (Middleville, Trenton Falls, Watertown etc.) occurs in large individuals, attaining a length and width of 12 mm.

4 Triplecia nucleus (Hall)

We refer a small Triplecia from the Snake Hill shale at North Albany to this species because of its subcircular outline, small size of

radial striae and the character of the fold, which is narrow, short and not produced anteriorly. T. nucleus is known from the middle Trenton at Middleville, N. Y., and the Rysedorph Hill conglomerate. Its occurrence in the Snake Hill shale is another link between that shale and the Trenton limestone.

Fig. 58

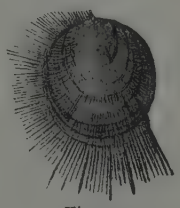


Fig. 59

Fig. 58 Triplecia nucleus (Hall), x2. Federal Signal Works, North Albany. Fig. 59 Schizambon albaniensis, nov. Holotype, x2.

5 Schizambon albaniensis nov.

Description. Shell of medium size, subelliptic in outline, about four-fifths as wide as long, widest in the middle, posterior end truncate with gently convex cardinal line. Foramen ovate in outline, situated about one-third of length of shell from beak. Surface furnished with coarse broad, smooth growth bands which are continued into long bristlelike spines which are straight and longest in the anterior region, toward the posterior region are curved slightly backward, reaching a second climax of length near the latero-cardinal angles, and continue as small spines along the cardinal line.

Measurements. Length of type-specimen 10.2 mm; greatest width 8.8 mm; length of cardinal margin 5 mm; length of anterior spines 3 mm.

Horizon and locality. Snake Hill beds at Watervliet near Albany (excavations for the shops of the Delaware and Hudson railroad) and Canajoharie shale at Rural cemetery at Albany.

Remarks. This species has before (Ruedemann, 1901, p. 529, 1912, p. 30, 63) been cited by the writer as Schizambon ? fissus var. canadensis Ami, which is now Schizambon canadensis, a species of the Gloucester shale. From this species our form as here figured from the Snake Hill beds differs in its outline, which is truncate posteriorly and subelliptic instead of ovate; and further in the direction of the spines in the posterior region which are curved, and continue along the cardinal line.

Winchell and Schuchert (1895, p. 361) have described as S ? dodgei a form from the Trenton limestone (Glens Falls limestone) at Sandy Hill, N. Y. This species, but little older than S. albaniensis, differs in being broader, more acute posteriorly and in possessing shorter and stouter spines.

Our material has not furnished any evidence as to the interior characters of the species. The foramen is large, situated relatively far forward (4 mm from posterior margin) and connected by a groove with the beak.

6 Tetranota bidorsata (Hall)

This species, originally described and figured by Hall (1847, p. 187) as Bucania bidorsata from the Lower Trenton at Middleville and Watertown is not uncommon in the Snake Hill shale at North Albany. The specimen figured has the lateral carinae so well developed, and has such a wide volution, that it suggests T. sexcarinata Ulrich, a western Stones River to Trenton form; other specimens of the Snake Hill shale appear, however, as good representatives of Hall's species. T. bidorsata is now known (Bassler 1916, p. 1271) to range from the Stones River into the Trenton and to occur from Nevada to New Jersey and Canada.

7 Kokenospira rara nov.

In describing Kokenia costalis, the monotype of the genus, Ulrich and Scofield (1897, p. 882) write: "We have seen but a single imperfect specimen of this species, and were it not that it belongs to a very interesting and easily recognized type, we would scarcely be justified in describing it."

The writer has to offer the same excuse of extreme biologic and paleogeographic interest attaching to the imperfect specimen before him, for it not only furnishes a new representative of the genus Kokenospira Bassler (=Kokenia Ulrich and Scofield, which name was preoccupied), but also suggests a northern paleogeographic connection for the isolated Snake Hill shale fauna of New York. The Snake Hill shale of the slate belt of eastern New York is of early Trenton age; so is the occurrence of K. costalis near Cannon Falls (Minnesota) in the Prosser limestone, and the further important discovery of a Kokenospira at Frobisher Bay, Baffin Land, by Schuchert (1900, p. 164). The genus is also represented in the Baltic region (K. esthona Koken) and has thus a distinctly subarctic distribution.

Fig. 60

Fig. 61

Fig. 60 Tetranota bidorsata (Hall). Nat. size. Fig. 61 Kokenospira rara nov. x2.

The specimen exhibits the following characters:

Description. Shell small, probably subglobular in form, 9 mm wide and 7.5 mm long, in vertically compressed condition; height not known; volutions broad enlarging gradually to the aperture; slit-band wide, smooth, slightly concave with filiform edges, the sides evenly and strongly convex to the umbilicus, which is too much compressed to show its nature. Aperture but slightly expanded apparently with but a shallow central emargination of the dorsal side. Surface on each side of slit-band with five (or more?) sharply elevated, outwardly curving revolving lines which alternate with finer ones that do not reach the aperture. Growth lines indistinct, except some very coarse lines paralleling the frontal margin.

From K. costalis our species is at once distinguished by the alternation of the revolving striae, and from K. esthona in the lesser prominence of the slit-band.

Schuchert states regarding the two Frobisher Bay specimens, which he identified with K. costalis, that they agree with the Minnesota form, of which there are two specimens in the National Museum, excepting the number of revolving lines. "Of these there are seven in the Minnesota specimens, while in the Arctic individuals there are from eleven to twelve, of which the fourth, sixth and eighth are the most prominent. The first, second, fourth, sixth and eighth revolving lines are continuous into the aperture, the others being interpolated on the last volution." This description leaves hardly any doubt that the Frobisher form is identical with ours, and further that the type thus marked by alternating striae should be distinguished from the Minnesota form with uniform lines.

Bibliography

Hall, James. Palaeontology of New York. v. 1, 1847

Winchell, N. H. & Schuchert, C. Geological and Natural History Survey of Minnesota. v. 3, pt 1, Palaeontology. Brachiopoda. 1895

Ulrich, E. O. & Scofield, W. S. ibid. v. 3, pt 2 Gastropoda, 1897, p. 813.

Schuchert, C. On the Lower Silurian (Trenton) Fauna of Baffin Land. Proc. U. S. Nat. Mus., *22*: 143. 1900

Ruedemann, R. Hudson River Beds near Albany and their Taxonomic Equivalents. N. Y. State Mus. Bul. *42*, 1901

Ruedemann, R. The Lower Silurian Shales of the Mohawk Valley. N. Y. State Mus. Bul. *162*, 1912

Bassler, R. S. Bibliographic Index of American Ordovician and Silurian Fossils. U. S. Nat. Mus. Bul. *92*, 1915

10 The Age of the Black Shales of the Lake Champlain Region

The black shales of the Champlain region form a continuous belt on the Vermont side of the lake, but appear only in a few small sporadic patches on the New York side. They form the top of the Ordovician series and are considered to this day as Utica shale (see Perkins, 1916, p. 208) for the good reason that they are black shales of the appearance of the Utica shale, rest upon Trenton limestone and while very barren, still contain in "Triarthrus becki" and "Diplograptus pristis," "Climacograptus bicornis," "Schizocrania filosa," "Orthoceras coraliferum" (see Perkins 1904, p. 106) species that would appear as fair evidence of Utica age.

The existence of a fine transitional series from the Trenton limestone to the Utica shale on the shore of Lake Champlain in the town of Panton, Vt., was pointed out to the writer by the late Dr Theodore White of Columbia University, and the locality visited in 1899. From the fossils then obtained, especially the presence of a Corynoides, the writer later (see Ruedemann, 1908, p. 37) inferred that the black shales intercalated in the top of the Trenton limestone series, represented low Utica and were of about the same age as the shale at the Rural cemetery at Albany, then also considered as early Utica. When this shale later (Ruedemann, 1912) was recognized to be of early Trenton age and placed with the Canajoharie shale, and it became further obvious that no Utica shale was developed as such in the Hudson valley and Utica beds there probably absent altogether, the question of the age of the so-called Utica shale of the Champlain region came up at once, and it has since been the conviction of Doctor Ulrich and the writer that there is no Utica shale in that region, but that the black shales, attaining such a great thickness in western Vermont, are older than Utica age.

The writer had in 1899 collected only from the transitional beds. but the Rev. E. W. Gould, then of Bristol, Vt., an enthusiastic student of geology, undertook in 1918, upon my suggestion, to collect

from the entire shale section. He found two exposures of shale, one extending from Arnolds bay northward (and southward) until rather abruptly replaced by the heavy Trenton limestone, apparently by a fault. This limestone farther north changes gradually through about 50 to 100 feet of transition beds (limestone beds, about 2 feet thick with soft black shale between) into the black shale.

Mr. Gould and the writer visited the section in 1919, collecting from the top of the Trenton limestone, the transition beds and all parts of the overlying black shale; the latter, taking the covered intervals at the north end in account, reaches 400 feet or more in thickness.

The top of the Trenton limestone, just below the transition beds consists of gray crystalline limestone and contains:

Mesotrypa quebecensis *Ami*
Rafinesquina *sp.*
Plectambonites sericeus (*Sowerby*)
Dalmanella rogata (*Sardeson*)
Parastrophia hemiplicata (*Hall*)
Protozyga exigua (*Hall*)
Calymmene senaria *Conrad*
Isotelus *sp.* (fragments)
Ceraurus pleurexanthemus *Green*
Aparchites minutissimus (*Hall*)
Leperditia *sp.*

On top of the limestone cliff, the writer had before collected:

Streptelasma corniculum (*Hall*)
Dalmanella *cf.* rogata (*Sardeson*)
Liospira americana (*Billings*)
Spyroceras bilineatum (*Hall*)
Bythocypris cylindrica (*Hall*)
Primitia *sp.*

The limestone at the beginning of the transition series has afforded:

Mesotrypa quebecensis *Ami*
Plectambonites sericeus (*Sowerby*)
Dinorthis meedsi *W. & S.* (Large form) c

The intercalated shale contains near the base:

Climacograptus strictus *Ruedemann* (putillus *auct.*)
Climacograptus spiniferus *Ruedemann* r (bicornis *auct.*)
Mesotrypa quebecensis *Ami*
Dalmanella rogata *Sardeson* c
Rafinesquina *sp.*

Leptobolus insignis *Hall* r
Rhynchotrema increbescens (*Hall*)
Ctenodonta levata (*Hall*) r
Primitiella unicornis *Ulrich* cc
Ulrichia bivertex (*Ulrich*) cc
Cryptolithus tesselatus *Green*
Bathyurus *cf.* spiniger (Hall) (glabella, free cheek, pygidium) r

In the higher transitional beds $\left\{\frac{I}{A\ 10} - \frac{I}{A\ 13}\right\}$:

Corynoides calicularis *Nicholson* c
Climacograptus strictus *Ruedemann* cc
Climacograptus spiniferus *Ruedemann* r
Climacograptus typicalis *Hall* rr (one specimen)
Diplograptus amplexicaulis *Hall* r
Lasiograptus eucharis (*Hall*) r
Mesograptus mohawkensis *Ruedemann* c
Leptobolus insignis *Hall* c
Schizambon *cf.* canadensis (*Ami*) rr
Lingula curta *Hall* c
Dalmanella rogata *Sardeson* c
Ulrichia bivertex (*Ulrich*) c
Lepidocoleus jamesi (*Hall and Whitfield*) rr

This fauna of the transitional zone is unmistakably that of the Canajoharie shale and corresponds to the lower division of the Canajoharie.

The black shale in the northern exposure, following the transitional beds has afforded to Mr. Gould:

Corynoides calicularis *Nicholson* c
Climacograptus strictus *Ruedemann* c
Mesograptus mohawkensis *Ruedemann* c
Glossograptus quadrimucronatus cornutus *Ruedemann* r
Lingula *sp.*
Schizambon canadensis (*Ami*) rr
Dalmanella rogata *Sardeson* c
Cryptolithus tesselatus *Green* cc
Calymmene senaria *Conrad*
Ceraurus *sp.*
Geisonoceras *sp.*

This upper shale mass is likewise undoubtedly of Canajoharie age and corresponds to the upper division as exposed in the Rural cemetery, Albany, N. Y.

Isolated outcrops of black calcareous shale along the east shore of Button bay, representing still higher beds of the shale formation contain:

Corynoides calicularis *Nicholson* cc
Climacograptus strictus *Ruedemann* c
Glossograptus quadrimucronatus (*Hall*)
Leptobolus insignis *Hall*
Worms (new species), like those at Rural Cemetery.

Finally, the 500 feet of black shale exposed from Arnolds bay to the Trenton limestone contains:

Mastigograptus *sp.* (fragment) rr
Corynoides calicularis *Nicholson* r
Diplograptus (Mesograptus) mohawkensis *Ruedemann* cc
Diplograptus (Amplexograptus) macer *Ruedemann* r
Diplograptus amplexicaulis *Hall* r
Diplograptus vespertinus *Ruedemann* c
Lasiograptus eucharis (*Hall*) c
Trematis terminalis *Hall* rr
Leptobolus insignis *Hall* r
Orthoceras *sp.* rr

This shale is also of Canajoharie age and appears to represent a still higher horizon than the north end of the northern shale exposures. Corynoides calicularis and Mesograptus mohawkensis are by far the most common fossils and were collected throughout the section, at over twenty stations.

Diplograptus (Amplexograptus) macer occurs in the upper beds.

It thus appears that the entire mass of black calcareous shale at Panton, representing three different horizons and altogether comprising probably as much as 1000 feet of rock, or a thickness corresponding to the maximal thickness recorded for the Vermont "Utica," belongs into the Canajoharie and not the Utica shale, and is thus of Trenton age.

On the New York side a few feet of black calcareous shale are exposed on the road from the village of Ticonderoga to Addison Junction (now railroad station Fort Ticonderoga). This shale contains:

Corynoides *sp. cf.* calicularis *Nicholson*
Climacograptus strictus *Ruedemann*
Glossograptus quadrimucronatus (*Hall*)
Lasiograptus eucharis (*Hall*)
Glossina trentonensis *Hall* c
Lingula *sp. nov. cf.* obtusa *Hall*
Ctenodonta *sp. cf.* levata (*Hall*)
Aparchites minutissimus (*Hall*) cc

This faunule indicates that also the black shale at the south end of Lake Champlain, near Ticonderoga, is referable to the Canajoharie shale.

A long exposure of black shale is found at the north end of Willsboro Point, about two-thirds down the lake, and half way between the Panton outcrops and the large outcrops of black shale on Grand Isle, Vermont. The contact or transition with the Trenton limestone was not observed. Unfortunately a strongly developed cleavage cuts this shale perpendicular to the bedding planes and this makes collecting extremely difficult. There were found, however:

Mesograptus mohawkensis *Ruedemann*
Leptobolus insignis *Hall*
Dalmanella rogata *Sardeson*
Liospira *sp.*
Triarthrus becki *Green*
Primitiella unicornis (*Ulrich*) cc
Aparchites minutissimus (*Hall*) cc

This faunule indicates the uppermost division of the Canajoharie shale and demonstrates that the latter extends northward beyond the middle of the Champlain basin.

There is but one outcrop of shale between Willsboro Point and the Canadian boundary line, that at Stony Point 1½ miles south of Rouses Point, and thus close to the international boundary. Here were found in hard, splintery, dark bluish gray calcareous shale:

Climacograptus spiniferus *Ruedemann* c
Glossograptus quadrimucronatus *Hall* c
Lasiograptus eucharis (*Hall*) r
Leptobolus insignis Hall r
Triarthrus becki *Green* cc

This faunule is characterized by the combination of Glossograptus quadrimucronatus, and Climacograptus spiniferus, with Lasiograptus eucharis and Triarthrus becki.

Climacograptus spiniferus and Triarthrus becki* point unmistakably to the eastern shale belt and a northern continuation of the Martinsburg, Snake Hill and Canajoharie shales of Pennsylvania and New York into this northern Champlain region. As to the age of the rock we infer from these two fossils that it is still older than Utica and probably homotaxial to late Trenton, a conclusion that is not contradicted by the other graptolites because they

*(Note). Triarthrus becki is a Snake hill and Canajoharie form The Utica and Frankfort form is T. eatoni Hall.

also occur in the Snake Hill and Canajoharie shales, though ranging considerably higher up.

We observed a continuation of this shale on the Vermont side of the lake at Windmill Point in the town of Alburg, where in like hard black calcareous shale the following species were obtained:

Glossograptus quadrimucronatus (*Hall*)
Lasiograptus eucharis (*Hall*)
Leptobolus insignis (*Hall*)

How far south this horizon extends in the black shale belt of Vermont we do not know, but suspect from some observations of ours that it reaches the southern extremity of Grand Isle.

One and one-half miles east of the outcrop at Windmill Point, along the lake shore at Alburg, Vermont, there were found in alternating black calcareous shale and black to dark gray impure limestone, mapped with the Utica shale by the Vermont Survey, the following forms:

Lingula (Palaeoglossa) trentonensis (*Conrad*)
Lingula *cf.* curta *Conrad* r
Dalmanella rogata *Sardeson* r
Protozyga exigua (*Hall*) r
Calymene senaria *Conrad* r
Odontopleura trentonensis (*Hall*) r
Primitiella unicornis *Ulrich* c
Primitia *sp.*
Ulrichia bivertex (*Ulrich*) r
Tetradella subquadrans radiomarginata[5] *Ruedemann* cc
Lepidocoleus *cf.* jamesi (*H. & W.*)

The most common and characteristic fossils of this faunule are Protozyga exigua, Primitiella unicornis and Tetradella subquadrans radiomarginata. These, in association with Lingula trentonensis, Odontopleura trentonensis and Ulrichia bivertex leave no doubt of the Trenton age of this dark calcare-

[5] This variety has all the characters of the Trenton species Tetradella subquadrans Ulrich, with the exception of the frill which bears distinct radiating lines, instead of being smooth, and is sharply bent up instead of being concave. Two specimens measured 2.2 mm by 1.1 mm and 2.1 mm by 1.1 mm, the variety thus having the exact dimensions of the typical form.

ous shale, which on lithologic grounds is considered as Utica shale (Perkins 1904, p. 117; 1916, p. 214).[6]

The Alburg shale contains an interesting combination of two of the characteristic ostracods of the Canajoharie shale in the Mohawk valley, namely, Primitiella unicornis and Ulrichia bivertex, with Trenton fossils not observed in the Canajoharie shale. The most common of these is Protozyga exigua, a middle Trenton species so far known only from the Watertown–Lowville region of New York. Also Lingula trentonensis is a middle Trenton species, and Odontopleura trentonensis is an element hitherto only known from the Trenton of the Bay of Quinte in Ontario. It is thus seen that the shale at Alburg forms a connecting link between the Canajoharie shale and the northern Trenton.

The shales at Cumberland Head near Plattsburg, were first noted by White (1900, p. 460) who considers them as either "very high Trenton or Utica" and cites a fauna, that is said to establish a connection between those of New York and Canada. White points out that similar rocks occur on Grand Isle, directly opposite Cumberland Head, and Cushing thinks that these are the transition beds mentioned from there by Perkins (1902, p. 114). Cushing (1905, pl. 13) has mapped these beds which he is inclined to consider as passage beds from the Trenton to the Utica as "Cumberland Head shale" and described them (ibid., p. 375) as consisting of blue-black slaty limestones and calcareous shales, with some firmer limestone bands. Ulrich, in the Revision, has correlated the Cumberland Head shale with the lower and middle Trenton, or in a general way, with the Canajoharie shale.

The writer had the pleasure of spending, in 1919, a day on Cumberland Head under the competent guidance of Prof. G. H. Hudson of Plattsburg, N. Y. It was seen that the Cumberland Head shales are lithologically very different from the Canajoharie shale of the Panton shore and the southern Champlain basin in general, for the prevailing element is slaty limestone and graptolite shale was not observed at all. The beds, as far as seen, are strangely barren in fossils. The following forms were collected:

[6] Professor Perkins is, however, aware of the fact that not all black shale in Vermont is of Utica age, for he states (ibid, p. 208): "In Vermont, as in Canada, New York and elsewhere, there is in many of the exposures no separation between the Trenton and the Utica for while the latter is almost wholly shale and the former limestone, yet in places there is compact limestone bearing Utica fossils and shale with Trenton fossils. Moreover in some localities the Trenton passes into the Utica so far as the contained fossils indicate."

Stromatocerium *sp.*
Lasiograptus eucharis (*Hall*)
Arthrostylus *cf.* obliquus *Ulrich* (fide Ulrich)
Leptobolus insignis *Hall*
Schizocrania filosa *Hall*
Dalmanella rogata *Sardeson*
Conularia trentonensis *Hall*
Isotelus *cf.* latus *Raymond* (pygidium & pleurae)

This faunule, small as it is, suggests a lower and middle Trenton age of the beds, as before inferred by Ulrich. It is then probable that these slaty limestones are in part at least equivalent to the Canajoharie shale. They represent, however, lithologically and faunistically, a different facies, and were clearly deposited under different conditions, if not in a separate basin, and should for that reason be distinguished by a name of their own.

The "Utica" shale forms a broad belt in Vermont from the Canadian boundary line southward over the islands of the lake, especially North Hero and Grand Isle (see Perkins 1904, p. 103) and attains there a considerable thickness. This shale is described by the Vermont geologists as being remarkably barren of fossils, Triarthrus becki and "Diplograptus" being the only fossils mentioned as common in places. This combination of Triarthrus becki and Glossograptus quadrimucronatus (the "Diplograptus pristis" of the earlier authors), as well as Climacograptus typicalis which the writer has collected on Grand Isle, indicate that the Stony Point shale reaches, on the Vermont side, in pretty strong development to the middle of the Champlain basin.

There is, however, little doubt that the Canajoharie shale which reaches such great thickness along the Panton shore, only 30 miles south of South Hero, is also still represented in the lower part of the black shale mass of the island[7] and its fauna is still recognizable in the shaly limestone at Alburg, close to the Canadian boundary.

The black Ordovician, so-called "Utica" shales of the Champlain basin consist then in the south entirely of Canajoharie shale, in the north prevailingly of the Stony Point shale. In the middle they may meet; the Stony Point shale resting upon the Canajoharie shale on Grand Isle and in the Vermont portion of the northern part of the basin; while on the New York side the Canajoharie shale is replaced by the peculiar facies of the Cumberland Head shale, the latter plac-

[7] The U. S. National Museum, for instance, contains specimens (no. 15244) of Lingula (Palaeoglossa) trentonensis (Conrad) from the "Utica" of Grand Isle, Lake Champlain.

ing itself between the lower division of the true Trenton limestone and the black Stony Point shale. It seems that the zone of the Cumberland Head shales extends northward over Point de Roche and merges into the dark impure limestone of the Alburg "Utica" belt described above.

11 The Graptolite Zones of the Ordovician Shale Belt of New York

There extends a broad belt of gray and black, red and green shale and slate through eastern New York. Beginning at the Vermont state line east of Whitehall, at the head of Lake Champlain, its course runs in southwest direction to the Hudson river which it follows from Glens Falls to the neighborhood of Poughkeepsie where it crosses the river and thence proceeds, between the Shawangunk mountains and the Highlands, into New Jersey. This belt is but a segment of the long zone of the Appalachian shaly deposits extending from the south bank of the lower St Lawrence river through the province of Quebec, Vermont, New York, Pennsylvania and Maryland into and beyond Virginia.

In the latitude of Saratoga Springs and Albany another belt of gray and black shales branches off from the master belt and, running first in west and then in northwest direction, it girdles the Adirondacks on the south and west following first the Mohawk river from its mouth to its source, then passing over to the Black River valley and again following this stream to the neighborhood of its mouth near the outlet of Lake Ontario.

Originally this entire mass of shales was designated as Hudson River shale. Through the discoveries of Emmons and Ford, but principally through the work of Walcott, the lower Cambrian (Georgian or Waucobian) rocks were separated from this thick terrane. Likewise the shale belt of the Mohawk and Black River valleys was early separated into three divisions, namely, the Utica, Frankfort and Lorraine shales; for the reason that these rocks contain sufficient fossils other than graptolites for discrimination. The Hudson River terrane of the eastern shale belt, however, proved almost entirely barren of fossils other than graptolites, and as a result of this unfavorable condition it remained undivided, the whole mass being placed above the Utica and in a general way correlated with the Lorraine.

Meanwhile the graptolite zones of the Ordovician had been worked out in great detail in both Great Britain and Sweden, and Lapworth, Matthew and Gurley[8] had pointed out that several of these zones are recognizable in Lower Canada and further that their correlation indicated a pre-Utica age.

A systematic study of the graptolites of the shale belt of New York, carried on for 25 years by the writer, has brought out a series of graptolite zones, fully comparable in number and order of succession to those of northern Europe; and it is the intention of the writer to give in this place a brief synopsis of these zones; since, with the discrimination of the zones of the Utica shale just accomplished, the work seems to have been brought to a certain degree of completion, for the present at least.

Normanskill Shale

In 1901[9] the Normanskill zone and the zone of Diplograptus amplexicaulis were distinguished in the Hudson river beds, and both correlated with the lower and middle Trenton limestone and considered equivalent to the Lower Dicellograptus shale of Europe. Later investigations[10] have shown that the Normanskill shale is evidently still older than Trenton age and consists of two zones, the lower of which is characterized by Nemagraptus gracilis (*zone of Nemagraptus gracilis*) while the upper has not yet received a name, since the two zones were not yet found together in a continuous section. The latter zone, however, is recognizable in several outcrops as that at Lansingburg[11] by the prevalence of species of Diplograptus and Climacograptus, or of Axonophora in general, over the forms without axes (Axonolipa), and by the absence of Nemagraptus gracilis. It may provisionally be termed *the zone of Corynoides gracilis* because this slender type of Corynoides is very common in this horizon, and has, in its typical form, not been observed in the preceding zone.

Recent discoveries in Virginia have indicated a still greater age for the zone of Nemagraptus gracilis than was anticipated here.

[8] For a bibliography on the graptolites, see Ruedemann, N. Y. State Mus. Memoir 7, 1904.

[9] R. Ruedemann, Hudson River Beds near Albany and their Taxonomic Equivalents. N. Y. State Mus. Bul. 42, 1901.

[10] H. P. Cushing and R. Ruedemann, Geology of Saratoga Springs and Vicinity, N. Y. State Mus. Bul. 169, 1914.

[11] See R. Ruedemann, Graptolites of New York, pt 2, N. Y. State Mus. Memoir II, p. 18. 1908.

Ulrich[12] has placed it above the typical Chazy and below the Lowville and Raymond[13] has correlated it with the Upper Chazy. The zone of Corynoides gracilis may then correspond to the Lowville and Leray periods. The later distinction of the Canajoharie and Snake Hill shales (see below, p. 122) has made it, at any rate, quite certain that all the Normanskill shale belongs below the Trenton.

Deep Kill Shale

In 1902 the writer[14] described the graptolite shales of Beekmantown age which he had discovered along Deep kill in Rensselaer county, N. Y., as the *Deep Kill shale*. These were divided into the following zones in descending order:

c Zone of Diplograptus dentatus and Cryptograptus antennarius.

b Zone of Didymograptus bifidus and Phyllograptus anna.

a Tetragraptus-zone.

In the correlation table (op. cit., p. 575) these zones were correlated with the Main Point Levis and Levis zones of Gurley and the St Anne zone of Lapworth, all in Quebec; the lower and upper Tetragraptus zones and Ellergill beds of Great Britain; and the Tetragraptus shale and the zones with Phyllograptus typus and Didymograptus bifidus, and that of Glossograptus and Didymograptus geminus in Sweden.

Schaghticoke Shale

In 1903, the presence of the zone of Dictyonema flabelliforme in the shale belt of New York was announced,[15] the beds being designated as Schaghticoke beds. The Zone of Dictyonema flabelliforme has a wide extension in northern Europe, notably Great Britain, Scandinavia and the Baltic provinces of Russia. It was there currently considered as marking the closing stage of the Cambrian, and this view was adopted by the writer. In the shale belt of New York it is the lowest graptolite horizon observable and the Schaghticoke beds rest directly upon the lower Cambrian. The occurrence, in the absence of other fossils, affords therefore no direct evidence

---

[12] E. O. Ulrich, Revision of the Palaeozic Systems. Bul. Geol. Soc. of America, 22: 512. 1911.

[13] Percy E. Raymond, Expedition to the Baltic Provinces of Russia and Scandinavia, pt 1. The correlation of the Ordovician strata of the Baltic basin with those of eastern North America. Bul. Mus. Comparative Zool., Harvard College, 56: 237. 1916.

[14] R. Ruedemann, Graptolite Facies of the Beekmantown Formation in Rensselaer County, N. Y., N. Y. State Mus. Bul. 52, 1902.

[15] R. Ruedemann, Cambric Dictyonema Fauna in the Slate Belt of Eastern New York, N. Y. State Mus. Bul. 69, 1903.

of its true age, although the lithologic identity of the rocks (green and black shale with thin limestone intercalations) with that of the Deep Kill shale gives these beds the appearance of introducing a new age rather than closing an old one. Meanwhile, however, it has been recognized in Europe, especially through Moberg's work, from the accompanying biota that the Dictyonema shale introduces an extensive Ordovician transgression and therefore is properly considered as the basal horizon of that period.

Subhorizons

It was already suggested in Bulletin 69 that the Schaghticoke beds may comprise two subhorizons, for there were found, on one hand, the shale filled with Dictyonema flabelliforme on the brow of the cliff forming the south bank of the Hoosic river bed; and, on the other, the shale with Staurograptus dichotomus Emmons (=Clonograptus proximatus Matthew) in the river bed itself. The latter shale contains a few specimens of Dictyonema flabelliforme acadicum Matthew which bring the subzone under the general division of the Dictyonema flabelliforme zone. On account of the contorted condition of the rocks, which did not allow a clear decision as to which horizon was the upper one, we refrained at the time from separating the two horizons. Since, however, in Europe the corresponding horizons, namely, that of Dictyonema flabelliforme forma typica, and that of Clonograptus tenellus, are already distinguished, and further it being obvious that Staurograptus dichotomus is a closely related, vicarious form of Clonograptus tenellus, it is preferable to separate the two horizons, for there can be hardly any doubt that the Staurograptus horizon is above that of Dictyonema flabelliforme. Westergard[16] even interpolates still a third zone, that of Clonograptus tenellus and Bryograptus hunnebergensis between the zone of Dictyonema flabelliforme and that of Bryograptus kjerulfi, Clonograptus tenellus and Dictyonema norvegicum. Hahn[17] came to a similar division of the zone from his exhaustive study of the Dictyonema fauna of Navy Island at St John, N. B. He was able to distinguish a fauna of Dictyonema flabelliforme acadica and conferta, associated with Staurograptus and another, younger one, of Dictyo-

[16] A. H. Westergard, Studier öfver Dictyograptusskiffern etc., Meddelande från Lunds Geol. Fältklubb, ser. B, no. 4, 1909.

[17] F. F. Hahn. On the Dictyonema-fauna of Navy Island, New Brunswick, Ann. N. Y. Acad. Sci., 32: 153. 1912.

nema flabelliforme ruedemanni, mixed with flabelliforme acadica, norwegica, desmograptoidea and Staurograptus.

We will thus distinguish the following zones:

b Zone of Staurograptus dichotomus.
a Zone of Dictyonema flabelliforme.

In part I of the Graptolites of New York (N. Y. State Mus. Mem. 7, 1904, p. 496), the writer has distinguished a *subhorizon of Clonograptus cf. flexilis,* a few fossils of which were found on the road from Albany to Defreestville. It was predicted there that the species of Clonograptus (flexilis, rigidus) described by Hall from Quebec would be found to represent a separate horizon between the Schaghticoke and Deep Kill horizons. Raymond[18] has since recognized this horizon as forming the base of the Point Levis series. He cites Clonograptus flexilis and C. rigidus, Tetragraptus quadribrachiatus, T. serra and T. approximatus as characteristic fossils. The next higher horizon at Point Levis is that with Phyllograptus typus, Tetragraptus quadribrachiatus and Didymograptus octobrachiatus. Also this horizon fails to be exposed in our Deep Kill section, but is probably present directly below our first horizon of the Tetragraptus bed, as indicated by the frequent occurrence there of the tetragrapti with the dominant species of Didymograptus.

Upon this follows our Tetragraptus zone of Bulletin 52. The detailed list of fossils, given in Memoir 7 (1904), page 504, however, brings out the fact that this zone is divisible into two subzones cited as bed 1 and bed 2. The first is characterized by Didymograptus nitidus and D. patulus and will be designated as the *subzone of Didymograptus nitidus and D. patulus.* The second (bed 2) is characterized by the abundance of Didymograptus extensus, Goniograptus thureaui, G. perflexilis and Tetragraptus fruticosus, T. quadribrachiatus and T. similis. We will distinguish it as *the subzone of Didymograptus extensus and Goniograptus thureaui.*

Upon this follows *the zone of Didymograptus bifidus* which is likewise divisible into two subzones, the first of which (bed 3) is characterized, besides Didymograptus bifidus, by Goniograptus geometricus, Tetragraptus

[18] Percy E. Raymond, The Succession of Faunas at Lévis, P. Q. Amer. Jour. Sci., 38: 523. 1914.

fruticosus, Didymograptus gracilis, D. ellesae and Phyllograptus anna. We will call it *the subzone of Goniograptus geometricus and Phyllograptus anna.*

The second subzone (bed 5) is characterized by Didymograptus similis, D. caduceus, Phyllograptus typus and P. anna, besides the dominant Didymograptus bifidus. This bed shows a strange recurrence of forms, noted much earlier elsewhere, especially in Phyllograptus typus (see Point Levis section, p. 120). We will call it *the subhorizon of Didymograptus similis and Phyllograptus typus.*

Finally, *the zone of Diplograptus dentatus* also distinctly falls into two subhorizons, namely:

a That of Phyllograptus angustifolius and Retiograptus tentaculatus (bed 6)

b That of Desmograptus, (D. cancellatus, D. intricatus, D. succulentus) *and Trigonograptus ensiformis.* (bed 7)

Another common form is Climacograptus antennarius.

There occurs, however, at the Ashhill quarry at Mount Moreno near Hudson (see Memoir 7, p. 449) a horizon of the zone of Diplograptus dentatus that is distinctly older than any of the two observed at the Deep Kill. This subhorizon is characterized by the dominancy of Diplograptus dentatus and Climacograptus pungens and the frequent occurrence of Ptilograptus plumosus and Didymograptus forcipiformis, the latter a new species. It may therefore be designated *the subhorizon of Climacograptus pungens and Didymograptus forcipiformis.*

The complete list of our Deep Kill horizons is then, in ascending order:

1 Zone of Clonograptus flexilis and Tetragraptus
2 Zone of Phyllograptus typus and Tetragraptus quadribrachiatus
} Tetragraptus beds

3 Zone of Didymograptus
a Subzone of D. nitidus, D. patulus
b Subzone of D. extensus, Goniogr. thureaui
} Didymograptus beds

4 Zone of Didymograptus bifidus
a Subzone of Goniogr. geometricus, Phyllogr. anna
b Subzone of Didymogr. similis, Phyllogr. typus

5 Zone of Diplograptus dentatus
- *a* Subzone of Climacogr. pungens, Didymogr. forcipiformis
- *b* Subzone of Phyllogr. angustifolius, Retiogr. tentaculatus
- *c* Subzone of Desmograptus and Trigonograptus ensiformis

Canajoharie shale, Magog shale

The writer had already in 1901 (Bulletin 42) distinguished *a zone with Diplograptus amplexicaulis* in the shale belt of the Hudson River region, and since Diplograptus amplexicaulis was then considered a fossil of the middle Trenton (it is properly referred to the lower Trenton), and it was found that this zone overlies the Normanskill shale, the latter was removed from its post-Utica position into a line with the middle and lower Trenton. There were further recognized the following horizons: one with Climacograptus caudatus, Cryptograptus tricornis, Triarthrus becki. (Mechanicville, Van Schaick Island, etc.); another with Diplograptus quadrimucronatus, D. "foliaceus," D. "putillus," Corynoides "curtus," Triarthrus becki (Rural Cemetery), and still another with Diplograptus "foliaceus" and Corynoides "curtus," exposed at Waterford. These horizons were erroneously referred to the Utica and the last to the Lorraine, in adherence to the conclusions of the earlier writers (see memoir 7 correlation table, facing p. 490).

In 1908[19] the beds from the Rural Cemetery, Van Schaick Island, as also those from Baker Falls which are characterized by Climacograptus spiniferus, were united under the zone of Diplograptus amplexicaulis and correlated with the Magog shale, exposed near the boundary of Quebec and New Hampshire, and which also contains Climacograptus caudatus and, in general, a fauna that is clearly younger than the typical Normanskill fauna and older than the Utica fauna. Climacograptus caudatus is in Europe a fossil of the zone of Dicranograptus clingani, which lies between that of Nemagraptus gracilis (our Normanskill) and that of Pleurograptus linearis (our Utica). This zone was therefore in a general way, in the before mentioned publication, placed in the middle and upper Trenton.

Field work in the lower Mohawk valley, preparatory to the mapping of the Saratoga quadrangle, led to a detailed study of this mass

[19] R. Ruedemann, Graptolites of New York, pt 2, N. Y. State Mus. Mem. 11, p. 29. 1908.

of pre-Utica shales in the upper Hudson and lower Mohawk valleys. The result of this work was published in 1912.[20]

In this paper the entire terrane of pre-Utica age, but of Utica aspect, in the lower Mohawk and upper Hudson River valley is distinguished as the *Canajoharie shale,* while the Lorraine facies, consisting of gray shale and sandstone, is termed the *Schenectady beds* and the similar beds of a more easterly situated basin or trough are called the *Snake Hill beds.* All these are of Trenton age, with the Schenectady beds possibly reaching also into Utica time.

The following graptolite horizons were distinguished in the Canajoharie shale, in descending order:

4 Zone of Climacograptus spiniferus, Diplograptus vespertinus, etc.

3 Zone of Lasiograptus eucharis, etc.

2 Zone of Glossograptus quadrimucronatus cornutus, Corynoides calicularis, etc.

1 Zone of Diplograptus amplexicaulis, Corynoides calicularis, etc.

It is, however, obvious from sections (published op. cit., p. 15 ff.) from Swartztown and Morphy creeks, that, in the shales exposed about 20 miles east of the typical Canajoharie sections, a zone precedes which is characterized by Mesograptus mohawkensis. This zone, while in the Morphy creek section reaching a considerable development, is in the Canajoharie section (ibid., p. 22) represented only in its last stage, on top of the basal Trenton (Glens Falls limestone). Since Diplograptus amplexicaulis does not appear until the upper part of the zone, the latter must precede the lowest zone of the Canajoharie shale, namely, that with Diplograptus amplexicaulis. We will distinguish this zone in the shales of Morphy and Swartztown creek as *zone of Mesograptus mohawkensis* and refer the zone, although but slightly represented at Canajoharie, to the Canajoharie shale.

An outcrop of shale at the Carlsbad spring near Saratoga (see Bulletin 169, p. 50) proves the presence of this zone also in the upper Hudson River valley.

The *Snake Hill beds* have furnished a rich fauna of other fossils than graptolites, but only meager graptolite faunules except in two cases. They have in common with the Canajoharie shale (see Bulletin 162, p. 64) the occurrence of Diplograptus amplexicaulis and Corynoides calicularis, but otherwise bear in both the graptolite and nongraptolite biota a

[20] R. Ruedemann, The Lower Siluric Shales of the Mohawk Valley. N. Y. State Mus. Bul. 162, 1912.

more distinctly easterly, Atlantic aspect. Here belong the shale on Van Schaick island with Cryptograptus tricornis insectiformis and the shale at Mechanicville (see Mem. 11, p. 32) with Climacograptus caudatus and Corynoides curtus comma. There is no doubt in our mind that these occurrences represent a zone that is older than any of the Canajoharie shale zones and that is equivalent or directly follows upon the shale exposed at Magog, for Climacograptus caudatus is found in Sweden only in the lowest of the three subzones of Dicranograptus clingani [21] and it is also in Great Britain [22] restricted to the zone of Dicranograptus clingani. We have further to see in Cryptograptus tricornis insectiformis, as well as in a number of the Magog species reminders of the nearness of the Normanskill fauna. This earlier zone of the Snake Hill beds may be distinguished as the *zone of Climacograptus caudatus.*

A higher horizon is exposed in black shales outcropping on both the east and west shores of Saratoga lake (see Bulletin 169, p. 97, 1914) north of Snake Hill. This shale has furnished an abundance of Dicranograptus nicholsoni, besides Diplograptus amplexicaulis, with varieties, Climacograptus spiniferus, mutations of Glossograptus quadrimucronatus, etc. This horizon of middle or late Trenton age may possibly correspond to the last one of the Canajoharie shale. The abundance of Dicranograptus nicholsoni which is a long range species is noteworthy in view of the fact that we shall meet another outburst of this European species in the middle Utica in an entirely different association of forms. We consider the combination, in a subzone, of Dicranograptus nicholsoni, Diplograptus amplexicaulis and Climacograptus spiniferus as of great interest, but of local importance only.

Utica Shale

Directly upon the Canajoharie shale in the middle Mohawk valley follows the *Utica shale.* This has been divided, in a monograph of the Cincinnatian of New York, now ready for the press[23] into three zones, namely,

---

[21] S. A. Tullberg; Skånes graptoliter I. Allmän öfversikt öfver de siluriska bildningarna i Skåne. Sver. Geol. Unders. Ser. C. no. 50, 1882

[22] Charles Lapworth, Gertrude L. Elles and Ethel M. R. Wood, A Monograph of British Graptolites, pt 5, Pal. Soc. 1906, p. 203.

[23] See also paper read before Pal. Soc. America, 1916. Abstract in: Geol. Soc. Amer. Bul., 28: 206.

1 Zone of Climacograptus typicalis, Glossograptus quadrimucronatus approximatus and Lasiograptus eucharis.

2 Zone of Dicranograptus nicholsoni.

3 Zone of Climacograptus pygmaeus and Glossograptus quadrimucronatus longispina.

To this is finally to be added, from the black shale of the Black River valley, the Deer River shale and Atwater Creek shale: *the zone of Climacograptus typicalis posterus and Glossograptus quadrimucronatus, forma typica.*

This zone also contains Diplograptus nexus and Climacograptus pygmaeus. It indicates a northeastern invasion.

The Lorraine beds contain graptolites but these are, for the most part, scattered and the beds not developed into graptolite shales.

Summarizing all the zones and subzones here enumerated, we get the following:

Table of Graptolite Zones of the Ordovician Shale Belt of New York

1 Schaghticoke shale

I	Zone of Dictyonema flabelliforme	
II	Zone of Staurograptus dichotomus	

2 Deep Kill shale

III	Zone of Clonograptus flexilis and Tetragraptus	Tetragraptus beds of Raymond
IV	Zone of Phyllograptus typus and Tetragraptus quadribrachiatus (zone inferred)	Tetragraptus beds of Raymond
V	Zone of Didymograptus	
	a Subzone of Didymograptus nitidus and Didymograptus patulus	
	b Subzone of Didymograptus extensus and Goniograptus thureaui	
VI	Zone of Didymograptus bifidus	
	a Subzone of Goniograptus geometricus and Phyllograptus anna	
	b Subzone of Didymograptus similis and Phyllograptus typus	
VII	Zone of Diplograptus dentatus and Phyllograptus angustifolius	
	a Subzone of Climacograptus pungens and Didymograptus forcipiformis	
	b Subzone of Phyllograptus angustifolius and Retiograptus tentaculatus	
	c Subzone of Desmograptus and Trigonograptus ensiformis.	

3 Normanskill shale

VIII	Zone of Nemagraptus gracilis
IX	Zone of Corynoides gracilis

4 Magog shale, Van Schaick Island and Mechanicville shale

X	Zone of Cryptograptus tricornis insectiformis and Climacograptus caudatus (Probably two subzones)

5 Canajoharie shale
- XI Zone of Mesograptus mohawkensis
- XII Zone of Diplograptus amplexicaulis, Corynoides calicularis, etc.
- XIII Zone of Glossograptus quadrimucronatus cornutus
- XIV Zone of Lasiograptus eucharis
- XV Zone of Climacograptus spiniferus, Diplograptus vespertinus, etc.

6 Utica shale
- XVI Zone of Climacograptus typicalis, Glossograptus quadrimucronatus approximatus and Lasiograptus eucharis
- XVII Zone of Dicranograptus nicholsoni
- XVIII Zone of Climacograptus pygmaeus and Glossograptus quadrimucronatus longispina

7 Deer River and Atwater Creek shales
- XIX Zone of Climacograptus typicalis posterus and Glossograptus quadrimucronatus, forma typica

There are here distinguished nineteen graptolite zones. Three of these are subdivided into well-characterized subzones, so that altogether twenty-three divisions of the graptolite shales arise. Indications of still more subdivisions are not lacking.

Correlation of Zones

The temptation is great, of course, to undertake a close comparison of these zones with those established in Great Britain, mainly by Lapworth, Marr and Elles, in Scandinavia by Linnarsson, Tullberg, Törnquist and Moberg and in Australia by T. S. Hall and others. A correlation of the principal divisions or large zones has been attempted in Memoir 7 (see correlation table opposite p. 470). A more detailed correlation of the smaller divisions would require a very close comparison of the faunas of the horizons on both sides of the Atlantic which we are not prepared to institute at present, though it is obviously very desirable; for there are very apparent discrepancies in the relative succession of the biota that, in part at least, are due to different interpretation of certain species.

A case in illustration is the determination of a zone of Diplograptus putillus Hall in Scandinavia below the zone of Nemagraptus gracilis. Diplograptus putillus is here a very late Ordovician, if not a Silurian (Richmond) form; for Hall's type specimens of this minute graptolite, which is more properly referred to Climacograptus, came from the Maquoketa shale. There occurs, however, a series of similar small forms here as far down as the Normanskill shale. The writer has, in the forthcoming Monograph of the Cincinnatian of New York distin-

guished three species among them, as they prove to be of considerable value for the differentiation of horizons.

The general succession of the graptolite zones is strikingly alike in all parts of the world, as pointed out by the writer in the Graptolites of New York, that is, the succession is everywhere, in ascending order:

1 Beds with Dictyonema flabelliforme
2 Clonograptus and Dichograptus horizons
3 Tetragraptus horizons
4 Didymograptus horizons
5 Phyllograptus horizons
6 Nemagraptus horizon
7 Horizons with Climacograptus and Diplograptus

This succession is distinctly a phylogenetic one, as far as the series from Dictyonema through Clonograptus, Dichograptus, Tetragraptus to Didymograptus is concerned. Likewise Phyllograptus and Nemagraptus are later aberrant branches enjoying a brief period of ascendency; and the development of the Axonophora, as represented by Climacograptus and Diplograptus is an important, new departure of the graptolites in the Middle Ordovician.

The recent investigations of Raymond in Quebec (op. cit., 1914) and of McLearn[24] in New Brunswick seem to bring out the interesting fact that differences in the succession and development of the graptolite zones are already observable between New York and Quebec and New Brunswick; for the lowest Didymograptus zone does not appear to be nearly so well developed at Levis as at the Deep Kill, and most of the large specimens of the "horizontal" species of Didymograptus are, at Levis, found in the subzone of Didymograptus bifidus (Raymond, op. cit., p. 528). McLearn (op. cit., p. 55) came even to the conclusion, that "the faunas all show greater affinity with those of northwestern Europe, especially with the Lake District of England and St Davids at Caermarthenshire, Wales, than with Quebec and New York faunas." In both Canadian localities the earlier appearance of the important zone graptolite Didymograptus bifidus is especially notable. Whether this is due to a longer persistence there of the horizontal Didymograpti, or an actual earlier appearance of the guide-fossil of the zone; it indicates differences in the composition of the zones due

[24] F. H. McLearn. The Lower Ordovician (Tetragrapus zone) at St John, New Brunswick, and the new genus Protistograptus. Amer. Jour. Sci., 40: 49. 1915.

to geographic causes. Nevertheless, the general parallelism of the series of larger zones remains a fact of great importance for both stratigraphic correlation and paleogeographic investigation.

Another problem, always prominent in discussions of graptolite horizons, is that of their correlation with the normal series of littoral beds. In Scandinavia this problem is solved to a large degree by the partial interlocking of the two facies. No such help has thus far been offered the investigators in our shale belt, so far as the Lower Ordovician graptolite shales are concerned, which, besides are involved in the complex folding and faulting of the region. Nevertheless, several clues for a correlation of these shales have been obtained, which may be mentioned in this place.

One of these is the finding of a specimen of Callograptus salteri Hall in the Tribes Hill limestone by Prof. H. F. Cleland (see Ruedemann, op. cit., 1904, p. 585). The graptolite has its principal development in bed 2 of the Deep Kill shale (zone of Didymograptus extensus and Goniograptus thureaui), although it extends above and below this bed. Its prevailing occurrence in bed 2 agrees well with the correlation of the Deep Kill shale with the Beekmantown in general, and that of the Tribes Hill with the lower Beekmantown (division B) in particular.

Another clue is furnished by the finding of a characteristic graptolite of the Deep Kill fauna in the Bellefonte section of Pennsylvania.[25] This form, Airograptus (Dictyonema) furciferum, occurs in beds 2 and 3 (zone of Didymograptus nitidus and patulus) and the lower part of the zone of Didymograptus bifidus, in the Deep Kill section. It is therefore found in about the middle of the Deep Kill section.

In Bulletin 189, the species has been placed near the top of the Nittany or the base of the Axeman, while Bassler, in the Bibliographic Index, since published, refers the graptolite to the Stonehenge or the basal division of the Bellefonte Beekmantown section. Doctor Ulrich, in a letter dated April 22d, informs me that the latter is the true position of the species, and that this fact agrees with the view, at which he arrived years ago, namely, that the Schaghticoke and Deep Kill graptolite shales hold a position below the middle of the Beekmantown. This view is principally based on evidence obtained in Arkansas. "There," Doctor Ulrich writes, "the Phyllograptus occurs in the Jefferson city dolomite. Above its zone, with an unconformity intervening, comes a zone with the

[25] R. Ruedemann. Paleontologic Contributions from the New York State Museum. N. Y. State Mus. Bul. 189, p. 20, 1916.

nearest approach to the Fort Cassin fauna that I have seen outside of the Champlain valley."

The last of the Deep Kill zones that with Diplograptus dentatus has probably to be excepted from this correlation with the lower and middle Beekmantown (see below, p. 130).

The shale with *Nemagraptus gracilis* has recently been found intercalated, as Athens shale, with fossiliferous limestones in Virginia, by Prof. S. L. Powell, and Drs E. O. Ulrich and George W. Stose.[26] Raymond, after a critical survey of the evidence furnished in Virginia, considers the section as placing the Normanskill definitely as post-middle Chazy and pre-Trenton and probably upper Chazy age.

The writer[27] has in former publications correlated the last zone of the Deep Kill shale that of Diplograptus dentatus, with the Chazy limestone on the ground that it is separated from the preceding zones by a most profound faunal change, namely, that from the Axonolipa to the abruptly appearing Axonophora indicating an important break between this and the preceding zone. Similarly in Great Britain the zone of Diplograptus dentatus is placed above the Arenig and in Sweden the middle Dicellograptus shales begin with a like outburst of Axonophora, as Diplograptus, Climacograptus, Glossograptus and Cryptograptus.

This correlation of the last zone of the Deep Kill shale with the Chazy seems also to be well supported by the stratigraphic nearness of this Deep Kill zone to the Normanskill shale at several localities in our shale belt, as notably on Mount Moreno near Hudson. The descent of the Normanskill shale into line with the upper Chazy, as advocated by Ulrich and Raymond, would then close the gap between the Deep Kill and Normanskill zones.

It is expected that the true position of the Rysedorph Hill conglomerate in regard to the upper Normanskill shale zone of Corynoides calicularis and succeeding graptolite shales, once clearly recognized will furnish sufficient data establishing the age of these shales and of those intervening between the Normanskill and Canajoharie shales.

The intercalation of graptolite shale, carrying Corynoides calicularis, Diplograptus amplexicaulis and Mesograptus mohawkensis in the top of the basal Trenton

[26] See S. L. Powell. Discovery of the Normanskill Graptolite Fauna in the Athens Shale of Southwestern Virginia. Jour. Geol., 1915, v. 23. Percy E. Raymond, op. cit., 1916, p. 234ff.

[27] See R. Ruedemann, op. cit., 1902, p. 573 and op. cit., 1904, chart facing p. 490 and p. 498.

or Glens Falls limestone in the Sprakers and Canajoharie sections[28] affords evidence of a direct nature as to the Trenton age of the Canajoharie shale.

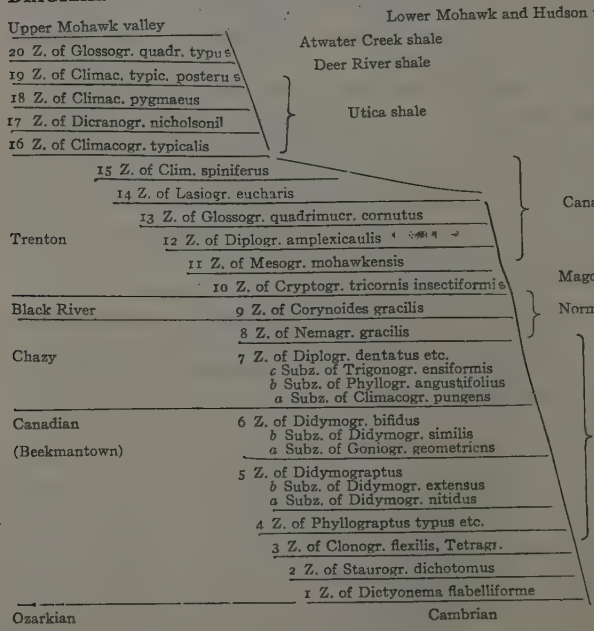
The Utica shale, like the Canajoharie and Snake Hill shales, carries mixed graptolite and nongraptolite faunas.

Summarizing these correlations of the graptolite facies with the littoral facies we get the following table of approximate correlations:

Correlation Table

Graptolite facies	*Littoral facies*
Utica shale	Utica shale
Canajoharie shale	Trenton limestone
Magog, Van Schaick Island, etc. shale	Glens Falls and Amsterdam limestone
Upper Normanskill shale	Lowville and Leray limestone
Lower Normanskill shale	Upper Chazy limestone
Upper Deep Kill (zone of Diplograptus dentatus)	Lower and middle Chazy limestone
Lower and middle Deep Kill shale	Beekmantown limestone and dolomite
Schaghticoke shale	Basal Beekmantown dolomite

DIAGRAM OF GRAPTOLITE ZONES OF ORDOVICIAN OF NEW YORK


Upper Mohawk valley
Lower Mohawk and Hudson valleys
20 Z. of Glossogr. quadr. typus
Atwater Creek shale
19 Z. of Climac. typic. posterus
Deer River shale
18 Z. of Climac. pygmaeus
17 Z. of Dicranogr. nicholsoni
16 Z. of Climacogr. typicalis
Utica shale
15 Z. of Clim. spiniferus
14 Z. of Lasiogr. eucharis
13 Z. of Glossogr. quadrimucr. cornutus
Canajoharie shale
Trenton
12 Z. of Diplogr. amplexicaulis
11 Z. of Mesogr. mohawkensis
Magog shale
10 Z. of Cryptogr. tricornis insectiformis
Black River
9 Z. of Corynoides gracilis
Normanskill shale
8 Z. of Nemagr. gracilis
Chazy
7 Z. of Diplogr. dentatus etc.
c Subz. of Trigonogr. ensiformis
b Subz. of Phyllogr. angustifolius
a Subz. of Climacogr. pungens
Canadian
(Beekmantown)
6 Z. of Didymogr. bifidus
b Subz. of Didymogr. similis
a Subz. of Goniogr. geometricus
Deep Kill shale
5 Z. of Didymograptus
b Subz. of Didymogr. extensus
a Subz. of Didymogr. nitidus
4 Z. of Phyllograptus typus etc.
3 Z. of Clonogr. flexilis, Tetragr.
2 Z. of Staurogr. dichotomus
Schaghticoke shale
1 Z. of Dictyonema flabelliforme
Ozarkian
Cambrian

[28] See Ruedemann, op. cit., 1912, p. 22.

New York State Museum

JOHN M. CLARKE, DIRECTOR

PUBLICATIONS

Packages will be sent prepaid except when distance or weight renders the same impracticable. On 10 or more copies of any one bulletin 20% discount will be given. Editions printed are only large enough to meet special claims and probable sales. When the sale copies are exhausted the price for the few reserve copies is advanced to that charged by secondhand booksellers, in order to limit their distribution to cases of special need. Such prices are inclosed in [ ]. All publications are in paper covers, unless binding is specified. Checks or money orders should be addressed and payable to The University of the State of New York.

Museum annual reports 1847– date. *All in print to* 1894, 50c *a volume*, 75c *in cloth;* 1894–*date, sold in sets only;* 75c *each for octavo volumes; price of quarto volumes on application.*

These reports are made up of the reports of the Director, Geologist, Paleontologist, Botanist and Entomologist, and museum bulletins and memoirs, issued as advance sections of the reports.

Director's annual reports 1904– date.

1904. 138p. 20c.
1905. 102p. 23pl. 30c.
1906. 186p. 41pl. 25c.
1907. (Bul. 121) 212p. 63pl. 50c.
1908. (Bul. 133) 234p. 39pl. map. 40c.
1909. (Bul. 140) 230p. 41pl. 2 maps, 4 charts.
Out of print
1910. (Bul. 149) 280p. il. 42pl. 50c.
1911. (Bul. 158) 218p. 49pl. 50c.
1912. (Bul. 164) 214p. 50pl. 50c.
1913. (Bul. 173) 158p. il. 29pl. 40c.
1914. (Bul. 177) 174p. il. 33pl. 45c.
1915. (Bul. 187) 192p. il. 58pl. 5 maps. 50c.
1916. (Bul. 196) 308p. il. 50pl. maps. 55c.
1917. (Bul. 207, 208) 211p. il. maps. 75c.
1918. (Bul. 219, 220) 309 p. il. 43 pl. 75c.
1919. (Bul. 227, 228)p. il. maps.

These reports cover the reports of the State Geologist and of the State Paleontologist. Bound also with the museum reports of which they form a part.

Geologist's annual reports 1881–date. Rep'ts 1, 3–13, 17–date, 8vo; 2, 14–16, 4to.

In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

The annual reports of the original Natural History Survey, 1837–41, are out of print.

Reports 1–4, 1881–84, were published only in separate form. Of the 5th report 4 pages were reprinted in the 39th museum report, and a supplement to the 6th report was included in the 40th museum report. The 7th and subsequent reports are included in the 41st and following museum reports, except that certain lithographic plates in the 11th report (1891) and 13th (1893) are omitted from the 45th and 47th museum reports.

Separate volumes of the following only are available.

Report	*Price*	*Report*	*Price*	*Report*	*Price*
12 (1892)	$.50	17	$.75	21	$.40
14	.75	18	.75	22	.40
15, 2v	2	19	.40	23	.45
16	1	20	.50	[*See* Director's annual reports]	

Paleontologist's annual reports 1899–date.

See first note under Geologist's annual reports.

Bound also with museum reports of which they form a part. Reports for 1899 and 1900 may be had for 20c each. Those for 1901–3 were issued as bulletins. In 1904 combined with the Director's report.

Entomologist's annual reports on the injurious and other insects of the State of New York 1882–date.

Reports 3–20 bound also with museum reports 40–46, 48–58 of which they form a part. Since 1898 these reports have been issued as bulletins. Reports 3–4, 17 are out of print, other reports with prices are:

Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$1	13	*Out of print*	24 (Bul. 134)	$.35
2	.30	14 (Bul. 23)	$.20	25 (" 141)	.35
5	.25	15 (" 31)	.15	26 (" 147)	.35
6	.15	16 (" 36)	.25	27 (" 155)	.40
7	.20	18 (" 64)	.20	28 (" 165)	.40
8	.25	19 (" 76)	.15	29 (" 175)	.45
9	.25	20 (" 97)	.40	30 (" 180)	.50
10	.35	21 (" 104)	.25	31 (" 186)	.35
11	.25	22 (" 110)	.25	32 (" 198)	.40
12	.25	23 (" 124)	.75	33 (" 202)	.35

Reports 2, 8–12 may also be obtained bound in cloth at 25c each in addition to the price given above.

Botanist's annual reports 1867–date.

Bound also with museum reports 21-date of which they form a part; the first Botanist's report appeared in the 21st museum report and is numbered 21. Reports 21–24, 29, 31–41 were not published separately.

Separate reports for 1871–74, 1876, 1888–98 are out of print. Report for 1899 may be had for 20c; 1900 for 50c. Since 1901 these reports have been issued as bulletins.

Descriptions and illustrations of edible, poisonous and unwholesome fungi of New York have also been published in volumes 1 and 3 of the 48th (1894) museum report and in volume 1 of the 49th (1895), 51st (1897), 52d (1898), 54th (1900), 55th (1901), in volume 4 of the 56th (1902), in volume 2 of the 57th (1903), in volume 4 of the 58th (1904), in volume 2 of the 59th (1905), in volume 1 of the 60th (1906), in volume 2 of the 61st (1907), 62d (1908), 63d (1909), 64th (1910), 65th (1911), v. 2 of the 66th (1912) reports. The descriptions and illustrations of edible and unwholesome species contained in the 49th, 51st and 52d reports have been revised and rearranged, and, combined with others more recently prepared, constitute Museum Memoir 4.

Museum bulletins 1887–date. 8vo. (1) *geology, economic geology, paleontology, mineralogy;* (2) *general zoology, archeology, miscellaneous;* (3) *botany,* (4) *entomology.*

Bulletins are grouped in the list on the following pages according to divisions. The divisions to which bulletins belong are as follows:

1 Zoology
2 Botany
3 Economic Geology
4 Mineralogy
5 Entomology
6 "
7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 " "
12 " "
13 Entomology
14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
18 Archeology
19 Geology
20 Entomology
21 Geology
22 Archeology
23 Entomology
24 "
25 Botany
26 Entomology
27 "
28 Botany
29 Zoology
30 Economic Geology
31 Entomology
32 Archeology
33 Zoology
34 Geology
35 Economic Geology
36 Entomology
37 "
38 Zoology
39 Paleontology
40 Zoology
41 Archeology
42 Geology
43 Zoology
44 Economic Geology
45 Geology and Paleontology
46 Entomology
47 "
48 Geology
49 Paleontology
50 Archeology
51 Zoology
52 Paleontology
53 Entomology
54 Botany
55 Archeology
56 Geology
57 Entomology
58 Mineralogy
59 Entomology
60 Zoology
61 Economic Geology
62 Miscellaneous
63 Geology
64 Entomology
65 Paleontology
66 Miscellaneous
67 Botany
68 Entomology
69 Paleontology
70 Mineralogy
71 Zoology
72 Entomology
73 Archeology
74 Entomology
75 Botany
76 Entomology
77 Geology
78 Archeology
79 Entomology
80 Paleontology
81 Geology
82 "
83 "
84 "
85 Economic Geology
86 Entomology
87 Archeology
88 Zoology
89 Archeology
90 Paleontology
91 Zoology
92 Geology and Paleontology
93 Economic Geology
94 Botany
95 Geology
96 "
97 Entomology
98 Mineralogy
99 Geology
100 Economic Geology
101 Geology
102 Economic Geology
103 Entomology
104 "
105 Botany
106 Geology
107 Geology and Paleontology
108 Archeology
109 Entomology
110 "
111 Geology
112 Economic Geology
113 Archeology
114 Geology
115 "
116 Botany
117 Archeology
118 Geology
119 Economic Geology
120 "
121 Director's report for 1907
122 Botany
123 Economic Geology
124 Entomology
125 Archeology
126 Geology
127 "
128 "
129 Entomology
130 Zoology
131 Botany
132 Economic Geology
133 Director's report for 1908
134 Entomology
135 Geology
136 Entomology
137 Geology
138 "
139 Botany
140 Director's report for 1909
141 Entomology
142 Economic Geology
143 "
144 Archeology
145 Geology
146 "
147 Entomology
148 Geology
149 Director's report for 1910
150 Botany
151 Economic Geology
152 Geology
153 "
154 "
155 Entomology
156 "
157 Botany
158 Director's report for 1911
159 Geology
160 "
161 Economic Geology
162 Geology
163 Archeology
164 Director's report for 1912
165 Entomology
166 Economic Geology
167 Botany
168 Geology
169 "
170 "
171 "
172 "
173 Director's report for 1913
174 Economic Geology

175 Entomology
176 Botany
177 Director's report for 1914
178 Economic Geology
179 Botany
180 Entomology
181 Economic Geology
182 Geology
183 Geology
184 Archeology
185 Geology
186 Entomology
187 Director's report for 1915
188 Botany
189 Paleontology
190 Economic Geology
191 Geology
192 "
193 "
194 Entomology
195 Geology
196 Director's report for 1916
197 Botany
198 Entomology
199 Economic Geology
200 Entomology
201 Economic Geology
202 Entomology
203–204 Economic Geology
205–206 Botany
207–208 Director's report for 1917
209–210 Geology
211–212 "
213–214 "
215–216 "
217–218 "
219–220 Director's report for 1918

Bulletins are also found with the annual reports of the museum as follows:

Bulletin	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*	*Bulletin*	*Report*
12–15	48, v. 1	78	57, v. 2	117	60, v. 3	165–67	66, v. 2
16, 17	50, v. 1	79	57, v. 1, pt 2	118	60, v. 1	168–70	66, v. 1
18, 19	51, v. 1	80	57, v. 1, pt 1	119–21	61, v. 1	171–76	67
20–25	52, v. 1	81, 82	58, v. 3	122	61, v. 2	177–80	68
26–31	53, v. 1	83, 84	58, v. 1	123	61, v. 1	181	69, v. 2
32–34	54, v. 1	85	58, v. 2	124	61, v. 2	182, 183	69, v. 1
35, 36	54, v. 2	86	58, v. 5	125	62, v. 3	184	69, v. 2
37–44	54, v. 3	87–89	58, v. 4	126–28	62, v. 1	185	69, v. 1
45–48	54, v. 4	90	58, v. 3	129	62, v. 2	186	69, v. 2
49–54	55	91	58, v. 4	130	62, v. 3	187	69, v. 1
55	56, v. 4	92	58, v. 3	131, 132	62, v. 2	188	69, v. 2
56	56, v. 1	93	58, v. 2	133	62, v. 1	189	69, v. 1
57	56, v. 3	94	58, v. 4	134	62, v. 2	190	69, v. 2
58	56, v. 1	95, 96	58, v. 1	135	63, v. 1		
59, 60	56, v. 3	97	58, v. 5	136	63, v. 2	*Memoir*	
61	56, v. 1	98, 99	59, v. 2	137, 138	63, v. 1	2	49, v. 3, and 50, v. 2
62	56, v. 4	100	59, v. 1	139	63, v. 2	3, 4	53, v. 2
63	56, v. 2	101	59, v. 2	140	63, v. 1	5, 6	57, v. 3
64	56, v. 3	102	59, v. 1	141–43	63, v. 2	7	57, v. 4
65	56, v. 2	103–5	59, v. 2	144	64, v. 2	8, pt 1	59, v. 3
66, 67	56, v. 4	106	59, v. 1	145, 146	64, v. 1	8, pt 2	59, v. 4
68	56, v. 3	107	60, v. 2	147, 148	64, v. 2	9, pt 1	60, v. 4
69	56, v. 2	108	60, v. 3	149	64, v. 1	9, pt 2	62, v. 4
70, 71	57, v. 1, pt 1	109, 110	60, v. 1	150–54	64, v. 2	10	60, v. 5
72	57, v. 1, pt 2	111	60, v. 2	155–57	65, v. 2	11	61, v. 3
73	57, v. 2	112	60, v. 1	158–60	65, v. 1	12, pt 1	63, v. 3
74	57, v. 1, pt 2	113	60, v. 3	161	65, v. 2	12, pt 2	66, v. 3
75	57, v. 2	114	60, v. 1	162	65, v. 1	13	63, v. 4
76	57, v. 1, pt 2	115	60, v. 2	163	66, v. 2	14, v. 1	65, v. 3
77	57, v. 1, pt 1	116	60, v. 1	164	66, v. 1	14, v. 2	65, v. 4

The figures at the beginning of each entry in the following list indicate its number as a museum bulletin.

Geology and Paleontology. 14 Kemp, J. F. Geology of Moriah and Westport Townships, Essex Co., N. Y., with notes on the iron mines. 38p. il. 7pl. 2 maps. Sept. 1895. *Free.*

19 Merrill, F. J. H. Guide to the Study of the Geological Collections of the New York State Museum. 164p. 119 pl. map. Nov. 1898. *Out of print.*

21 Kemp, J. F. Geology of the Lake Placid Region. 24p. 1pl. map. Sept. 1898. *Free.*

34 Cumings, E. R. Lower Silurian System of Eastern Montgomery County; Prosser, C. S. Notes on the Stratigraphy of Mohawk Valley and Saratoga County, N. Y. 74p. 14pl. map. May 1900. 15c.

39 Clarke, J. M.; Simpson, G. B. & Loomis, F. B. Paleontologic Papers 1. 72p. il. 16pl. Oct. 1900. 15c.

Contents: Clarke, J. M. A Remarkable Occurrence of Orthoceras in the Oneonta Beds of the Chenango Valley, N. Y.
—— Paropsonema cryptophya; a Peculiar Echinoderm from the Intumescens-zone (Portage Beds) of Western New York.
— Dictyonine Hexactinellid Sponges from the Upper Devonic of New York.
— The Water Biscuit of Squaw Island, Canandaigua Lake, N. Y.
Simpson, G. B. Preliminary Descriptions of New Genera of Paleozoic Rugose Corals.
Loomis, F. B. Siluric Fungi from Western New York.

42 Ruedemann, Rudolf. Hudson River Beds near Albany and Their Taxonomic Equivalents. 116p. 2pl. map. Apr. 1901. 25c.

45 Grabau, A. W. Geology and Paleontology of Niagara Falls and Vicinity. 286p. il. 18pl. map. Apr. 1901. 65c; *cloth*, 90c.

48 Woodworth, J. B. Pleistocene Geology of Nassau County and Borough of Queens. 58p. il. 8pl. map. Dec. 1901. *Out of print.*

49 Ruedemann, Rudolf; Clarke, J. M. & Wood, Elvira. Paleontologic Papers 2. 240p. 13pl. Dec. 1901. *Out of print.*

Contents: Ruedemann, Rudolf. Trenton Conglomerate of Rysedorph Hill.
Clarke, J. M. Limestones of Central and Western New York Interbedded with Bituminous Shales of the Marcellus Stage.
Wood, Elvira. Marcellus Limestones of Lancaster, Erie Co., N. Y.
Clarke, J. M. New Agelacrinites.
—— Value of Amnigenia as an Indicator of Fresh-water Deposits during the Devonic of New York, Ireland and the Rhineland.

52 Clarke, J. M. Report of the State Paleontologist 1901. 280p. il. 10pl. map. 1 tab. July 1902. 40c.

56 Merrill, F. J. H. Description of the State Geologic Map of 1901, 42p. 2 maps, tab. Nov. 1902. *Free.*

63 Clarke, J. M. & Luther, D. D. Stratigraphy of Canandaigua and Naples Quadrangles. 78p. map. June 1904. 25c.

65 Clarke, J. M. Catalogue of Type Specimens of Paleozoic Fossils in the New York State Museum. 848p. May 1903. $1.20, *cloth.*

69 —— Report of the State Paleontologist 1902. 464p. 52pl. 7 maps. Nov. 1903. $1, *cloth.*

77 Cushing, H. P. Geology of the Vicinity of Little Falls, Herkimer Co. 98p. il. 15 pl. 2 maps. Jan. 1905. 30c.

80 Clarke, J. M. Report of the State Paleontologist 1903. 396p. 29pl. 2 maps. Feb. 1905. 85c, *cloth.*

81 Clarke, J. M. & Luther, D. D. Watkins and Elmira Quadrangles. 32p. map. Mar. 1905. 25c.

82 —— Geologic Map of the Tully Quadrangle. 40p. map. Apr. 1905. 20c.

83 Woodworth, J. B. Pleistocene Geology of the Mooers Quadrangle. 62p. 25pl. map. June 1905. 25c.

84 —— Ancient Water Levels of the Champlain and Hudson Valleys. 206p. il. 11pl. 18 maps. July 1905. 45c.

90 Ruedemann, Rudolf. Cephalopoda of Beekmantown and Chazy Formations of Champlain Basin. 224p. il. 38pl. May 1906. 75c, *cloth.*

92 Grabau, A. W. Guide to the Geology and Paleontology of the Schoharie Region. 314p. il. 26pl. map. Apr. 1906. 75c, *cloth.*

95 Cushing, H. P. Geology of the Northern Adirondack Region. 188p. 15pl. 3 maps. Sept. 1905. 30c.

96 Ogilvie, I. H. Geology of the Paradox Lake Quadrangle. 54p. il. 17pl. map. Dec. 1905. 30c.

99 Luther, D. D. Geology of the Buffalo Quadrangle. 32p. map. May 1906. 20c.

101 —— Geology of the Penn Yan-Hammondsport Quadrangles. 28p. map. July 1906. *Out of print.*

106 Fairchild, H. L. Glacial Waters in the Erie Basin. 88p. 14pl. 9 maps. Feb. 1907. *Out of print.*

107 Woodworth, J. B.; Hartnagel, C. A.; Whitlock, H. P.; Hudson, G. H.; Clarke, J. M.; White, David & Berkey, C. P. Geological Papers. 388p. 54pl. map. May 1907. 90c, *cloth.*

Contents: Woodworth, J. B. Postglacial Faults of Eastern New York.
Hartnagel, C. A. Stratigraphic Relations of the Oneida Conglomerate.
—— Upper Siluric and Lower Devonic Formations of the Skunnemunk Mountain Region.
Whitlock, H. P. Minerals from Lyon Mountain, Clinton Co.
Hudson, G. H. On Some Pelmatozoa from the Chazy Limestone of New York.
Clarke, J. M. Some New Devonic Fossils.
—— An Interesting Style of Sand-filled Vein.
—— Eurypterus Shales of the Shawangunk Mountains in Eastern New York.
White, David. A Remarkable Fossil Tree Trunk from the Middle Devonic of New York.
Berkey, C. P. Structural and Stratigraphic Features of the Basal Gneisses of the Highlands.

111 Fairchild, H. L. Drumlins of New York. 60p. 28pl. 19 maps. July 1907. *Out of print.*

114 Hartnagel, C. A. Geologic Map of the Rochester and Ontario Beach Quadrangles. 36p. map. Aug. 1907. 20c.

115 Cushing, H. P. Geology of the Long Lake Quadrangle. 88p. 20pl. map. Sept. 1907. 25c.
118 Clarke, J. M. & Luther, D. D. Geologic Maps and Descriptions of the Portage and Nunda Quadrangles including a map of Letchworth Park. 50p. 16pl. 4 maps. Jan. 1908. 35c.
126 Miller, W. J. Geology of the Remsen Quadrangle. 54p. il. 11pl. map. Jan. 1909. 25c.
127 Fairchild, H. L. Glacial Waters in Central New York. 64p. 27pl. 15 maps. Mar. 1909. 40c.
128 Luther, D. D. Geology of the Geneva-Ovid Quadrangles. 44p. map. Apr. 1909. 20c.
135 Miller, W. J. Geology of the Port Leyden Quadrangle, Lewis County, N. Y. 62p. il. 11pl. map. Jan. 1910. 25c.
137 Luther, D. D. Geology of the Auburn-Genoa Quadrangles. 36p. map. Mar. 1910. 20c.
138 Kemp, J. F. & Ruedemann, Rudolf. Geology of the Elizabethtown and Port Henry Quadrangles. 176p. il. 20pl. 3 maps. Apr. 1910. *Out of print.*
145 Cushing, H. P.; Fairchild, H. L.; Ruedemann, Rudolf & Smyth, C. H. Geology of the Thousand Islands Region. 194p. il. 62pl. 6 maps. Dec. 1910. $1, *cloth.*
146 Berkey, C. P. Geologic Features and Problems of the New York City (Catskill) Aqueduct. 286p. il. 38pl. maps. Feb. 1911. 75c; $1, *cloth.*
148 Gordon, C. E. Geology of the Poughkeepsie Quadrangle. 122p. il. 26pl. map. Apr. 1911. 30c.
152 Luther, D. D. Geology of the Honeoye Wayland Quadrangles. 30p. map. Oct. 1911. 20c.
153 Miller, William J. Geology of the Broadalbin Quadrangle, Fulton-Saratoga Counties, New York. 66p. il. 8pl. map. Dec. 1911. 25c.
154 Stoller, James H. Glacial Geology of the Schenectady Quadrangle. 44p. 9pl. map. Dec. 1911. 20c.
159 Kemp, James F. The Mineral Springs of Saratoga. 80p. il. 3 pl. Apr. 1912. 15c.
160 Fairchild, H. L. Glacial Waters in the Black and Mohawk Valleys. 48p. il. 8pl. 14 maps. May 1912. 50c.
162 Ruedemann, Rudolf. The Lower Siluric Shales of the Mohawk Valley. 152p. il. 15pl. Aug. 1912. 35c.
168 Miller, William J. Geological History of New York State. 130p. 43pl. 10 maps. Dec. 1913. 40c.
169 Cushing, H. P. & Ruedemann, Rudolf. Geology of Saratoga Springs and Vicinity. 178p. il. 20pl. map. Feb. 1914. 40c.
170 Miller, William J. Geology of the North Creek Quadrangle. 90p. il. 14pl. Feb. 1914. 25c.
171 Hopkins, T. C. The Geology of the Syracuse Quadrangle. 80p. il. 20pl. map. July 1914. 25c.
172 Luther, D. D. Geology of the Attica and Depew Quadrangles. 32p. map. Aug. 1914. 15c.
182 Miller, William J. The Geology of the Lake Pleasant Quadrangle. 56p. il. 10pl. map. Feb. 1916. 25c.
183 Stoller, James H. Glacial Geology of the Saratoga Quadrangle. 50p. il. 12pl. map. Mar. 1, 1916. 25c.
185 Martin, James C. The Precambrian Rocks of the Canton Quadrangle. 112p. il. 20pl. map. May 1, 1916. 30c.
189 Ruedemann, Rudolf. Paleontologic Contributions from the New York State Museum. 225p. il. 36 pl. Sept. 1916. 50c.
191 Cushing, H. P. Geology of the Vicinity of Ogdensburg. 64p. il. 6pl. map. Nov. 1916. 25c.
192 Miller, William J. Geology of the Blue Mountain Quadrangle. 68p. il. 11pl. map. Dec. 1916. 25c.
193 —— The Adirondack Mountains. 97p. il. 30pl. 2 maps. Jan. 1917. 35c.
195 Fairchild, H. L. Postglacial Features of the Upper Hudson Valley. 22p. map. Mar. 1, 1917. 25c.

209–210 Fairchild, H. L. Pleistocene Marine Submergence of the Hudson, Champlain and St Lawrence Valleys. 75p. il. 25pl. maps. May–June 1918. 50c.
211–212 Miller, W. J. Geology of the Lake Placid Quadrangle. 104p. il. 23pl. map. July–Aug. 1918. 35c.
213–214 —— Geology of the Schroon Lake Quadrangle. 102p. il. 14pl. map. Sept.–Oct. 1918. 35c.
215–216 Stoller, J. H. Glacial Geology of the Cohoes Quadrangle. 49p. il. 2pl. map. Nov.–Dec. 1919. 25c.
217–218 Chadwick, George H. Paleozoic Rocks of the Canton Quadrangle. 60p. il. 12pl. map. Jan.–Feb. 1919. 35c.
221–222 Clarke, John M. Organic Dependence and Disease. Their origin and significance.
225–226 Berkey, C. P. & Rice, Marion. Geology of the West Point Quadrangle. p. pl. map. Sept.–Oct. 1919.
Crosby, W. O. Geology of Long Island. *In preparation.*
Luther, D. D. Geology of the Phelps Quadrangle. *In preparation.*
—— Geology of the Eden-Silver Creek Quadrangles. *Prepared.*
—— Geology of the Brockport-Hamlin and Albion-Oak Orchard Quadrangles. *Prepared.*
—— Geology of the Medina-Ridgeway and Lockport-Olcott Quadrangles. *Prepared.*
—— Geology of the Caledonia-Batavia Quadrangles. *Prepared.*
Ruedemann, R. The Utica and Lorraine Formations of New York. *In preparation.*
Kemp, James F. Geology of the Mount Marcy Quadrangle. *In press.*
Miller, W. J. Geology of the Lyon Mountain Quadrangle. *Prepared.*
Cushing, H. P. Geology of the Gouverneur Quadrangle. *Prepared.*
Kemp, James F. & Alling, H. L. Geology of the Ausable Quadrangle. *Prepared.*
Smyth, C. H. jr & Buddington, A. F. Geology of the Lake Bonaparte Quadrangle. *Prepared.*
Miller, W. J. Geology of the Russell quadrangle. *Prepared.*
Cook, J. H. Surface Geology of the Albany-Berne Quadrangles. *Prepared.*
Buddington, A. F. Geology of the Lowville Quadrangle. *Prepared.*
Fairchild, H. L. Evolution of the Susquehanna River. *Prepared.*

Economic Geology. 3 Smock, J. C. Building Stone in the State of New York, 154 p. Mar. 1888. 30c.
7 —— First Report on the Iron Mines and Iron Ore Districts in the State of New York. 78p. map. June 1889. 25c.
10 —— Building Stone in New York. 210p. map, tab. Sept. 1890. 40c.
11 Merrill, F. J. H. Salt and Gypsum Industries of New York. 94p. 12pl. 2 maps, 11 tab. Apr. 1893. 50c.
12 Ries, Heinrich. Clay Industries of New York. 174p. il. 1pl. map. Mar. 1895. 30c.
15 Merrill F. J. H. Mineral Resources of New York. 240p. 2 maps. Sept. 1895. [50c]
17 —— Road Materials and Road Building in New York. 52p. 14pl. 2 maps. Oct. 1897. 15c.
30 Orton, Edward. Petroleum and Natural Gas in New York. 136p. il. 3 maps. Nov. 1899. 15c.
35 Ries, Heinrich. Clays of New York; Their Properties and Uses. 456p. 140pl. map. June 1900. $1, *cloth.*
44 —— Lime and Cement Industries of New York; Eckel, E. C. Chapters on the Cement Industry. 332p. 101pl. 2 maps. Dec. 1901. 85c, *cloth.*
61 Dickinson, H. T. Quarries of Bluestone and Other Sandstones in New York. 114p. 18pl. 2 maps. Mar. 1903. 35c.
85 Rafter, G. W. Hydrology of New York State. 902p. il. 44pl. 5 maps. May 1905. $1.50, *cloth.*
93 Newland, D. H. Mining and Quarry Industry of New York. 78p. July 1905. *Out of print.*
100 McCourt, W. E. Fire Tests of Some New York Building Stones. 40p. 26pl. Feb. 1906. 15c.

102 Newland, D. H. Mining and Quarry Industry of New York 1905. 162p. June 1906. 25c.
112 —— Mining and Quarry Industry of New York 1906. 82p. July 1907. *Out of print.*
119 —— & Kemp, J. F. Geology of the Adirondack Magnetic Iron Ores with a Report on the Mineville-Port Henry Mine Group. 184p. 14pl. 8 maps. Apr. 1908. 35c.
120 Newland, D. H. Mining and Quarry Industry of New York 1907. 82p. July 1908. 15c.
123 —— & Hartnagel, C. A. Iron Ores of the Clinton Formation in New York State. 76p. il. 14pl. 3 maps. Nov. 1908. 25c.
132 Newland, D. H. Mining and Quarry Industry of New York 1908. 98p. July 1909. 15c.
142 —— Mining and Quarry Industry of New York for 1909. 98p. Aug. 1910. 15c.
143 —— Gypsum Deposits of New York. 94p. 20pl. 4 maps. Oct. 1910. 35c.
151 —— Mining and Quarry Industry of New York 1910. 82p. June 1911. 15c.
161 —— Mining and Quarry Industry of New York 1911. 114p. July 1912. 20c.
166 —— Mining and Quarry Industry of New York 1912. 114p. Aug. 1913. 20c.
174 —— Mining and Quarry Industry of New York 1913. 111p. Dec. 1914. 20c.
178 —— Mining and Quarry Industry of New York 1914. 88p. Nov. 1915. 15c.
181 —— The Quarry Materials of New York. 212p. 34pl. Jan. 1916. 40c.
190 —— Mining and Quarry Industry of New York 1915. 92p. Oct. 1916. 15c.
—— Mining and Quarry Industry of New York (see Mus. Bul. 196).
199 Alling, Harold L. The Adirondack Graphite Deposits. 150p. il. July 1, 1917. 30c.
201 Smyth, C. H., jr. Genesis of the Zinc Ores of the Edwards District, St Lawrence County, N. Y. 32p. 12pl. Sept. 1, 1917. 20c.
203–204 Colony, R. J. High Grade Silica Materials for Glass, Refractories and Abrasives. 31p. il. Nov.–Dec. 1917. 15c.
223–224 Newland, D. H. The Mineral Resources of the State of New York. 315p. il. 3 maps. July-August 1919. 50c.
—— The Iron Regions of Orange and Putnam Counties. *Prepared.*

Mineralogy. 4 Nason, F. L. Some New York Minerals and Their Localities. 22p. 1pl. Aug. 1888. *Free.*
58 Whitlock, H. P. Guide to the Mineralogic Collections of the New York State Museum. 150p. il. 39pl. 11 models. Sept. 1902. 40c.
70 —— New York Mineral Localities. 110p. Oct. 1903. 20c.
98 —— Contributions from the Mineralogic Laboratory. 38p. 7pl. Dec. 1905. *Out of print.*

Zoology. 1 Marshall, W. B. Preliminary List of New York Unionidae. 20p Mar. 1892. *Free.*
9 —— Beaks of Unionidae Inhabiting the Vicinity of Albany, N. Y. 30p. 1pl. Aug. 1893. *Free.*
29 Miller, G. S. jr. Preliminary List of New York Mammals. 124p. Oct. 1899. 15c.
33 Farr, M. S. Check List of New York Birds. 224p. Apr. 1900. 25c.
38 Miller, G. S. jr. Key to the Land Mammals of Northeastern North America. 106p. Oct. 1900. 15c.
40 Simpson, G. B. Anatomy and Physiology of Polygyra albolabris and Limax maximus and Embryology of Limax maximus. 82p. 28pl. Oct. 1901. 25c.
43 Kellogg, J. L. Clam and Scallop Industries of New York. 36p. 2pl. map. Apr. 1901. *Free.*
51 Eckel, E. C. & Paulmier, F. C. Catalogue of Reptiles and Batrachians of New York. 64p. il. 1pl. Apr. 1902. *Out of print.*
Eckel, E. C. Serpents of Northeastern United States.
Paulmier, F. C. Lizards, Tortoises and Batrachians of New York.
60 Bean, T. H. Catalogue of the Fishes of New York. 784p. Feb. 1903. $1 *cloth.*

71 Kellogg, J. L. Feeding Habits and Growth of Venus mercenaria. 30p 4 pl. Sept. 1903. *Free.*

83 Letson, Elizabeth J. Check List of the Mollusca of New York. 116p. May 1905. 20c.

91 Paulmier, F. C. Higher Crustacea of New York City. 78p. il. June 1905. 20c.

130 Shufeldt, R. W. Osteology of Birds. 382p. il. 26pl. May 1909. 50c.

Entomology. 5 Lintner, J. A. White Grub of the May Beetle. 34p. il. Nov. 1888. *Free.*

6 —— Cut-worms. 38p. il. Nov. 1888. *Free.*

13 —— San José Scale and Some Destructive Insects of New York State. 54p. 7pl. Apr. 1895. 15c.

20 Felt, E. P. Elm Leaf Beetle in New York State. 46p. il. 5pl. June 1898. *Free.*

See 57.

23 —— 14th Report of the State Entomologist 1898. 150p. il. 9pl. Dec. 1898. 20c.

24 —— Memorial of the Life and Entomologic Work of J. A. Lintner Ph.D. State Entomologist 1874–98; Index to Entomologist's Reports 1–13. 316p. 1pl. Oct. 1899. 35c.

Supplement to 14th report of the State Entomologist.

26 —— Collection, Preservation and Distribution of New York Insects. 36p. il. Apr. 1899. *Out of print.*

27 —— Shade Tree Pests in New York State. 26p. il. 5pl. May 1899. *Out of print.*

31 —— 15th Report of the State Entomologist 1899. 128p. June 1900. 15c.

36 —— 16th Report of the State Entomologist 1900. 118p. 16pl. Mar. 1901. 25c.

37 —— Catalogue of Some of the More Important Injurious and Beneficial Insects of New York State. 54p. il. Sept. 1900. *Free.*

46 —— Scale Insects of Importance and a List of the Species in New York State. 94p. il. 15pl. June 1901. 25c.

47 Needham, J. G. & Betten, Cornelius. Aquatic Insects in the Adirondacks. 234p. il. 36pl. Sept. 1901. 45c.

53 Felt, E. P. 17th Report of the State Entomologist 1901. 232p. il. 6pl. Aug. 1902. *Out of print.*

57 —— Elm Leaf Beetle in New York State. 46p. il. 8 pl. Aug. 1902. *Out of print.*

This is a revision of Bulletin 20 containing the more essential facts observed since that was prepared.

59 —— Grapevine Root Worm. 40p. 6pl. Dec. 1902. 15c.

See 72.

64 —— 18th Report of the State Entomologist 1902. 110p. 6 pl. May 1903. 20c.

68 Needham, J. G. *& others.* Aquatic Insects in New York. 322p. 52pl. Aug. 1903. 80c, *cloth.*

72 Felt, E. P. Grapevine Root Worm. 58p. 13pl. Nov. 1903. 20c.

This is a revision of Bulletin 59 containing the more essential facts observed since that was prepared.

74 —— & Joutel, L. H. Monograph of the Genus Saperda. 88p. 14pl. June 1904. 25c.

76 Felt, E. P. 19th Report of the State Entomologist 1903. 150p. 4pl. 1904. 15c.

79 —— Mosquitoes or Culicidae of New York. 164p. il. 57pl. tab. Oct. 1904. 40c.

86 Needham, J. G. *& others.* May Flies and Midges of New York. 352p. il. 37pl. June 1905. 80c, *cloth.*

97 Felt, E. P. 20th Report of the State Entomologist 1904. 246p. il. 19pl. Nov. 1905. 40c.

103 —— Gipsy and Brown Tail Moths. 44p. 10pl. July 1906. *Out of print.*
104 —— 21st Report of the State Entomologist 1905. 144p. 10pl. Aug. 1906. 25c.
109 —— Tussock Moth and Elm Leaf Beetle. 34p. 8pl. Mar. 1907. *Out of print.*
110 —— 22d Report of the State Entomologist 1906. 152p. 3pl. June 1907. 25c.
124 —— 23d Report of the State Entomologist 1907. 542p. il. 44pl. Oct. 1908. 75c.
129 —— Control of Household Insects. 48p. il. May 1909. *Out of print.*
134 —— 24th Report of the State Entomologist 1908. 208p. il. 17pl. Sept. 1909. 35c.
136 —— Control of Flies and Other Household Insects. 56p. il. Feb. 1910. 15c.

This is a revision of Bulletin 129 containing the more essential facts observed since that was prepared.

141 Felt, E. P. 25th Report of the State Entomologist 1909. 178p. il. 22pl. July 1910. 35c.
147 —— 26th Report of the State Entomologist 1910. 182p. il. 35pl. Mar. 1911. 35c.
155 —— 27th Report of the State Entomologist 1911. 198p. il. 27pl. Jan. 1912. 40c.
156 —— Elm Leaf Beetle and White-Marked Tussock Moth. 35p. 8pl. Jan. 1912. 20c.
165 —— 28th Report of the State Entomologist 1912. 266p. 14pl. July 1913. 40c.
175 —— 29th Report of the State Entomologist 1913. 258p. 16pl. April 1915. 45c.
180 —— 30th Report of the State Entomologist 1914. 336p. il. 19pl. Jan. 1916. 50c.
186 —— 31st Report of the State Entomologist 1915. 215p. il. 18pl. June 1, 1916. 35c.
194 —— Household and Camp Insects. 84p. il. Feb. 1, 1917. 15c.
198 —— 32d Report of the State Entomologist 1916. 276p. il. 8pl. June 1, 1917. 40c.
200 —— Key to American Insect Galls. 310p. il. 16pl. August 1917. *Out of print.*
202 —— 33d Report of the State Entomologist 1917. 240p. il. 12pl. 35c.
Betten, Cornelius. Report on the Aquatic Insects of New York. *In press.*
Felt, E. P. Report of the State Entomologist for 1918. *Prepared.*

Botany. 2 Peck, C. H. Contributions to the Botany of the State of New York. 72p. 2pl. May 1887. 20c.
8 —— Boleti of the United States. 98p. Sept. 1889. *Out of print.*
25 —— Report of the State Botanist 1898. 76p. 5pl. Oct. 1899. *Out of print.* 20c.
28 —— Plants of North Elba. 206p. map. June 1899. 20c.
54 —— Report of the State Botanist 1901. 58p. 7pl. Nov. 1902. 40c.
67 —— Report of the State Botanist 1902. 196p. 5pl. May 1903. 50c.
75 —— Report of the State Botanist 1903. 70p. 4pl. 1904. 40c.
94 —— Report of the State Botanist 1904. 60p. 10pl. July 1905. 40c.
105 —— Report of the State Botanist 1905. 108p. 12pl. Aug. 1906. 50c.
116 —— Report of the State Botanist 1906. 120p. 6pl. July 1907. 35c.
122 —— Report of the State Botanist 1907. 178p. 5pl. Aug. 1908. 40c.
131 —— Report of the State Botanist 1908. 202p. 4pl. July 1909. 40c.
139 —— Report of the State Botanist 1909. 116p. 10pl. May 1910. 45c.
150 —— Report of the State Botanist 1910. 100p. 5pl. May 1911. 30c.
157 —— Report of the State Botanist 1911. 140p. 9pl. Mar. 1912. 35c.
167 —— Report of the State Botanist 1912. 138p. 4pl. Sept. 1913. 30c.
176 —— Report of the State Botanist 1913. 78p. 17pl. June 1915. 20c.
179 —— Report of the State Botanist 1914. 108p. 1 pl. Dec. 1915. 20c.
188 House, H. D. Report of the State Botanist 1915. 118p. il. 4pl. Aug. 1, 1916. 30c.

197 - - — Report of the State Botanist 1916. 122p. 11pl. May 1, 1917. 30c.
205-206 —— Report of the State Botanist 1917. 169p. 23pl. Jan.–Feb. 1918. 50c.

Archeology. 16 Beauchamp, W. M. Aboriginal Chipped Stone Implements of New York. 86p. 23pl. Oct. 1897. 25c.
18 —— Polished Stone Articles Used by the New York Aborigines. 104p. 35pl. Nov. 1897. 25c.
22 —— Earthenware of the New York Aborigines. 78p. 33pl. Oct. 1898. 25c.
32 —— Aboriginal Occupation of New York. 190p. 16pl. 2 maps. Mar. 1900. 30c.
41 —— Wampum and Shell Articles Used by New York Indians. 166p. 28pl. Mar. 1901. *Out of print.*
50 —— Horn and Bone Implements of the New York Indians. 112p. 43pl. Mar. 1902. *Out of print.*
55 —— Metallic Implements of the New York Indians. 94p. 38pl. June 1902. 25c.
73 —— Metallic Ornaments of the New York Indians. 122p. 37pl. Dec. 1903. *Out of print.*
78 —— History of the New York Iroquois. 340p. 17pl. map. Feb. 1905. *Out of print.*
87 —— Perch Lake Mounds. 84p. 12pl. Apr. 1905. 20c.
89 —— Aboriginal Use of Wood in New York. 190p. 35pl. June 1905. *Out of print.*
108 —— Aboriginal Place Names of New York. 336p. May 1907. *Out of print.*
113 —— Civil, Religious and Mourning Councils and Ceremonies of Adoption. 118p. 7pl. June 1907. 25c.
117 Parker, A. C. An Erie Indian Village and Burial Site. 102p. 38pl. Dec. 1907. 30c.
125 Converse, H. M. & Parker, A. C. Iroquois Myths and Legends. 196p. il. 11pl. Dec. 1908. 50c.
144 Parker, A. C. Iroquois Uses of Maize and Other Food Plants. 120p. il. 31pl. Nov. 1910. *Out of print.*
163 —— The Code of Handsome Lake. 144p. 23pl. Nov. 1912. 25c.
184 —— The Constitution of the Five Nations. 158p. 8pl. April 1, 1916. 30c.
—— The Archeologic History of the State of New York. *In press.*

Miscellaneous. 62 Merrill, F. J. H. Directory of Natural History Museums in United States and Canada. 236p. Apr. 1903. 30c.
66 Ellis, Mary. Index to Publications of the New York State Natural History Survey and New York State Museum 1837–1902. 418p. June 1903. 75c, *cloth.*
New York State Defense Council Bulletin No. 1. Report on the Pyrite and Pyrrhotite Veins in Jefferson and St Lawrence Counties, New York, by A. F. Buddington. p.40, il. Nov. 1917. *Free.*
New York State Defense Council Bulletin No. 2. The Zinc-Pyrite Deposits of the Edwards District, New York, by David H. Newland. p.72, il. Nov. 1917. *Free.*

Museum memoirs 1889–date. 4to.
1 Beecher, C. E. & Clarke, J. M. Development of Some Silurian Brachiopoda. 96p. 8pl. Oct. 1889. $1.
2 Hall, James & Clarke, J. M. Paleozoic Reticulate Sponges. 350p. il. 70pl. 1898. $2, *cloth.*
3 Clarke, J. M. The Oriskany Fauna of Becraft Mountain, Columbia Co., N. Y. 128p. 9pl. Oct. 1900. 80c.
4 Peck, C. H. N. Y. Edible Fungi, 1895-99. 106p. 25pl. Nov. 1900. 75c
This includes revised descriptions and illustrations of fungi reported in the 49th, 51st and 52d reports of the State Botanist.

5 Clarke, J. M. & Ruedemann, Rudolf. Guelph Formation and Fauna of New York State. 196p. 21pl. July 1903. $1.50, *cloth.*

6 Clarke, J. M. Naples Fauna in Western New York. 268p. 26pl. map. 1904. $2, *cloth.*

7 Ruedemann, Rudolf. Graptolites of New York. Pt 1 Graptolites of the Lower Beds. 350p. 17pl. Feb. 1905. $1.50, *cloth.*

8 Felt, E. P. Insects Affecting Park and Woodland Trees. v. I. 460p. il. 48pl. Feb. 1906. $2.50, *cloth*; v. 2. 548p. il. 22pl. Feb. 1907. $2, *cloth.* $4 for the two volumes.

9 Clarke, J. M. Early Devonic of New York and Eastern North America. Pt 1. 366p. il. 70pl. 5 maps. Mar. 1908. $2.50, *cloth*; Pt 2. 250pl. il. 36p. 4 maps. Sept. 1909. $2, *cloth.*

10 Eastman, C. R. The Devonic Fishes of the New York Formations. 236p. 15pl. 1907. $1.25, *cloth.*

11 Ruedemann, Rudolf. Graptolites of New York. Pt 2 Graptolites of the Higher Beds. 584p. il. 31pl. 2 tab. Apr. 1908. $2.50, *cloth.*

12 Eaton, E. H. Birds of New York. v. I. 501p. il. 42pl. Apr. 1910. *Out of print.* v. 2, 719p. il. 64pl. July 1914. *Out of print.* 106 colored plates in portfolio $1.

13 Whitlock, H. P. Calcites of New York. 190p. il. 27pl. Oct. 1910. $1, *cloth.*

14 Clarke, J. M. & Ruedemann, Rudolf. The Euryperida of New York. v. I Text. 440p. il. v. 2. Plates. 188p. 88pl. Dec. 1912. $4, *cloth.*

15 House, Homer D. Wild Flowers of New York. v. 1. 185p. 143pl. il; v. 2. 177 p. 121pl. il. 1918. $7 for the two volumes.

Goldring, W. Monograph of the Devonian Crinoids of New York. *Prepared.*

Pilsbry, H. L. Monograph of the Land and Fresh Water Mollusca of the State of New York. *In preparation.*

Natural History of New York. 30 v. il. pl. maps. 4to. Albany 1842–94.

DIVISION 1 ZOOLOGY. De Kay, James E. Zoology of New York; or, The New York Fauna; comprising detailed descriptions of all the animals hitherto observed within the State of New York with brief notices of those occasionally found near its borders, and accompanied by appropriate illustrations. 5v. il. pl. maps. sq. 4to. Albany 1842–44. *Out of print.*

Historical introduction to the series by Gov. W. H. Seward. 178p.

v. 1 pt 1 Mammalia. 131 + 46p. 33pl. 1842.

300 copies with hand-colored plates.

v. 2 pt 2 Birds. 12 + 380p. 141pl. 1844.

Colored plates.

v. 3 pt 3 Reptiles and Amphibia. 7 + 98p. pt 4 Fishes. 15 + 415p. 1842.

pt 3–4 bound together.

v. 4 Plates to accompany v. 3. Reptiles and Amphibia. 23pl. Fishes 79pl. 1842.

300 copies with hand-colored plates.

v. 5 pt 5 Mollusca. 4 + 271p. 40pl. pt 6 Crustacea. 70p. 13pl. 1843–44.

Hand-colored plates; pt 5–6 bound together.

DIVISION 2 BOTANY. Torrey, John. Flora of the State of New York; comprising full descriptions of all the indigenous and naturalized plants hitherto discovered in the State, with remarks on their economical and medical properties. 2v. il. pl. sq. 4to. Albany 1843. *Out of print.*

v. 1 Flora of the State of New York. 12 + 484p. 72pl. 1843.

300 copies with hand-colored plates.

v. 2 Flora of the State of New York. 572p. 89pl. 1843.

300 copies with hand-colored plates.

DIVISION 3 MINERALOGY. Beck, Lewis C. Mineralogy of New York; comprising detailed descriptions of the minerals hitherto found in the State of New York, and notices of their uses in the arts and agriculture. il. pl. sq. 4to. Albany 1842. *Out of print.*

v. 1 pt 1 Economical Mineralogy. pt 2 Descriptive Mineralogy. 24 + 536p. 1842.
8 plates additional to those printed as part of the text.

DIVISION 4 GEOLOGY. Mather, W. W.; Emmons, Ebenezer; Vanuxem, Lardner & Hall, James. Geology of New York. 4v. il. pl. sq. 4to. Albany 1842–43. *Out of print.*
v. 1 pt 1 Mather, W. W. First Geological District. 37 + 653p. 46pl. 1843.
v. 2 pt 2 Emmons, Ebenezer. Second Geological District. 10 + 437p. 17pl. 1842.
v. 3 pt 3 Vanuxem, Lardner. Third Geological District. 306p. 1842.
v. 4 pt 4 Hall, James. Fourth Geological District. 22 + 683p. 19pl. map. 1843.

DIVISION 5, AGRICULTURE. Emmons, Ebenezer. Agriculture of New York; comprising an account of the classification, composition and distribution of the soils and rocks and the natural waters of the different geological formations, together with a condensed view of the meteorology and agricultural productions of the State. 5v. il. pl. sq. 4to. Albany 1846–54. *Out of print.*
v. 1 Soils of the State, Their Composition and Distribution. 11 + 371p. 21pl. 1846.
v. 2 Analysis of Soils, Plants, Cereals etc. 8 + 343 + 46p. 42pl. 1849.
With hand-colored plates.
v. 3 Fruits etc. 8 + 340p. 1851.
v. 4 Plates to accompany v. 3. 95pl. 1851.
Hand-colored.
v. 5 Insects Injurious to Agriculture. 8 + 272p. 50pl. 1854.
With hand-colored plates.

DIVISION 6 PALEONTOLOGY. Hall, James. Paleontology of New York. 8v. il. pl. sq. 4to. Albany 1847–94. *Bound in cloth.*
v. 1 Organic Remains of the Lower Division of the New York System. 23 + 338p. 99pl. 1847. *Out of print.*
v. 2 Organic Remains of Lower Middle Division of the New York System. 8 + 362p. 104pl. 1852. *Out of print.*
v. 3 Organic Remains of the Lower Helderberg Group and the Oriskany Sandstone. pt 1, text. 12 + 532p. 1859. [$3.50]
——pt 2. 142 pl. 1861. [$2.50]
v. 4 Fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 11 + 1 + 428p. 69pl. 1867. $2.50.
v. 5 pt 1 Lamellibranchiata 1. Monomyaria of the Upper Helderberg, Hamilton and Chemung Groups. 18 + 268p. 45pl. 1884. $2.50.
—— —— Lamellibranchiata 2. Dimyaria of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 62 + 293p. 51pl. 1885. $2.50.
—— pt 2 Gasteropoda, Pteropoda and Cephalopoda of the Upper Helderberg, Hamilton, Portage and Chemung Groups. 2v. 1879. v. 1, text. 15 + 492p.; v. 2. 120pl. $2.50 for 2 v.
—— & Simpson, George B. v. 6 Corals and Bryozoa of the Lower and Upper Helderberg and Hamilton Groups. 24 + 298 p. 67pl. 1887. $2.50.
—— & Clarke, John M. v. 7 Trilobites and Other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung and Catskill Groups. 64 + 236p. 46pl. 1888. Cont. supplement to v. 5, pt 2. Pteropoda, Cephalopoda and Annelida. 42p. 18pl. 1888. $2.50.
—— & Clarke, John M. v. 8 pt 1. Introduction to the Study of the Genera of the Paleozoic Brachiopoda. 16 + 367p. 44pl. 1892. $2.50.
—— & Clarke, John M. v. 8 pt 2 Paleozoic Brachiopoda. 16 + 394p. 64pl. 1894. $2.50. *Out of print.*

Catalogue of the Cabinet of Natural History of the State of New York and of the Historical and Antiquarian Collection annexed thereto. 242p. 8vo. 1853.

Handbooks 1893–date.

New York State Museum, 52p. il. 1902. *Out of print.*

Outlines history and work of the museum with list of staff 1902.

Paleontology. 12p. 1899. *Out of print.*

Brief outline of State Museum work in paleontology under heads: Definition; Relation to biology; Relation to stratigraphy; History of paleontology in New York.

Guide to Excursions in the Fossiliferous Rocks of New York. 124p. 1899. *Out of print.*

Itineraries of 32 trips covering nearly the entire series of Paleozoic rocks, prepared specially for the use of teachers and students desiring to acquaint themselves more intimately with the classic rocks of this State.

Entomology. 16p. 1899. *Out of print.*

Economic Geology. 44p. 1904. *Out of print.*

Insecticides and Fungicides. 20p. 1909. *Free.*

Classification of New York Series of Geologic Formations. 32p. 1903. *Out of print.* Revised edition. 96p. 1912. *Free.*

Guides

Guide to the Mineral Collections, prepared by Herbert P. Whitlock. p. 45. 1916. *Free.*

Guide to the Collections of General Geology and Economic Geology, prepared by Robert W. Jones, p. 31. 1917. *Free.*

Guide to the Paleontological Collections, prepared by Rudolf Ruedemann. p. 35, il. 1916. *Free.*

Geologic maps. Merrill, F. J. H. Economic and Geologic Map of the State of New York; issued as part of Museum Bulletin 15 and 48th Museum Report, v. 1. 59 x 67 cm. 1894. Scale 14 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Quarries of Stone Used for Building and Road Metal. 1897. *Out of print.*

—— Map of the State of New York Showing the Distribution of the Rocks Most Useful for Road Metal. 1897. *Out of print.*

—— Geologic Map of New York. 1901. Scale 5 miles to 1 inch. *In atlas form,* $2. *Lower Hudson sheet* 50c.

Separate sheets of this map are available at 50c each, as follows:

Ontario West	Finger Lakes	Delaware
Niagara	Long Island	Adirondack
South Western	St Lawrence	Hudson Mohawk
Ontario East	Central	Lower Hudson

(Note) The Ontario West is not colored as it has no surface geology.

The lower Hudson sheet, geologically colored, comprises Rockland, Orange, Dutchess, Putnam, Westchester, New York, Richmond, Kings, Queens and Nassau counties, and parts of Sullivan, Ulster and Suffolk counties; also northeastern New Jersey and part of western Connecticut.

—— Map of New York Showing the Surface Configuration and Water Sheds. 1901. Scale 12 miles to 1 inch. 15c.

—— Map of the State of New York Showing the Location of Its Economic Deposits. 1904. Scale 12 miles to 1 inch. 15c.

Geologic maps on the United States Geological Survey topographic base. Scale 1 in. = 1 m. Those marked with an asterisk have also been published separately.

Albany county. 1898. *Out of print.*

Area around Lake Placid. 1898.

Vicinity of Frankfort Hill [parts of Herkimer and Oneida counties]. 1899.

Rockland county. 1899.

Amsterdam quadrangle. 1900.

*Parts of Albany and Rensselaer counties. 1901. *Out of print.*

*Niagara river. 1901. 25c.

Part of Clinton county. 1901.

Oyster Bay and Hempstead quadrangles on Long Island. 1901.

Portions of Clinton and Essex counties. 1902.

Part of town of Northumberland, Saratoga co. 1903.

Union Springs, Cayuga county and vicinity. 1903.

*Olean quadrangle. 1903. *Free.*
*Becraft Mt with 2 sheets of sections. (Scale 1 in. = ½ m.) 1903. 20c.
*Canandaigua-Naples quadrangles. 1904. 20c.
*Little Falls quadrangle. 1905. *Free.*
*Watkins-Elmira quadrangles. 1905. 20c.
*Tully quadrangle. 1905. *Out of print.*
*Salamanca quadrangle. 1905. *Out of print.*
*Mooers quadrangle. 1905. *Free.*
Paradox Lake quadrangle. 1905.
*Buffalo quadrangle. 1906. *Out of print.*
*Penn Yan-Hammondsport quadrangles. 1906. 20c.
*Rochester and Ontario Beach quadrangles. 1907. 20c.
*Long Lake quadrangle. 1907. *Out of print.*
*Nunda-Portage quadrangles. 1908. 20c.
*Remsen quadrangle. 1908. *Free.*
*Geneva-Ovid quadrangles. 1909. 20c.
*Port Leyden quadrangle. 1910. *Free.*
*Auburn-Genoa quadrangles. 1910. 20c.
*Elizabethtown and Port Henry quadrangles. 1910. 15c.
*Alexandria Bay quadrangle. 1910. *Free.*
*Cape Vincent quadrangle. 1910. *Free.*
*Clayton quadrangle. 1910. *Free.*
*Grindstone quadrangle. 1910. *Free.*
*Theresa quadrangle. 1910. *Out of print.*
*Poughkeepsie quadrangle. 1911. *Free.*
*Honeoye-Wayland quadrangles. 1911. 20c.
*Broadalbin quadrangle. 1911. *Free.*
*Schenectady quadrangle. 1911. *Free.*
*Saratoga-Schuylerville quadrangles. 1914. 20c.
*North Creek quadrangle. 1914. *Free.*
*Syracuse quadrangle. 1914. *Free.*
*Attica-Depew quadrangles. 1914. 20c.
*Lake Pleasant quadrangle. 1916. *Free.*
*Saratoga quadrangle. 1916. *Free.*
*Canton quadrangle. 1916. *Free.*
*Brier Hill, Ogdensburg and Red Mills quadrangles. 1916. 15c.
*Blue Mountain quadrangle. 1916. *Free.*
*Glens Falls, Saratoga, Schuylerville, Schenectady and Cohoes quadrangles. 1917. 20c.
Lake Placid quadrangle. 1919.
Schroon Lake quadrangle. 1919.
Cohoes quadrangle. 1920.
Canton quadrangle. 1920.

INDEX

Accessions to collections, 32–38
Adirondacks, geology, 8
Albany county, postglacial deposits and drainage, 8
Alburg shale, 114
Alling, Harold L., work of, 8, 9
Archeological Association, 14
Archeological excavations on Boughton Hill, 11–13
Archeology, report on, 28–29
Ausable quadrangle, 8

Bagg, Rufus M., work of, 9
Beauchamp, William M., Cornplanter medal bestowed on, 14
Berkey, Charles P., work of, 8
Bonaventure cherts, 9
Botany, report on, 17–18
Boughton Hill, archeological excavations, 11–13
Buddington, A. F., work of, 8
Burmaster, Everett R., work of, 11

Canajoharie faunas, additions, 101–8
Canajoharie shale, 111, 122–24, 130
Caryocaris salter, 95–100
Cephalopods, fossil, on sex distinction in, 68
Chamberlin, T. C., cited, 47
Clinton formation and fauna, 8
Codling moth, 22–23
Colony, R. J., work of, 8
Cook, David B., work of, 13
Cook, John H., work of, 8
Corn insects, 20
Cornplanter medal, 14
Crinoids, Devonian, monograph, 9
Crop pests, 22
Cushing, H. P., work of, 8

Deep kill shale, 118
Devonian crinoids, monograph, 9
Dewey, Alvin H., Cornplanter medal bestowed on, 14
Dolgeville beds, fauna, 100–1
Dystactospongia radicosa nov., 101–3

Entomology, report on, 18–26
Essex county, postglacial deposits and drainage, 8
Ethnology, report on, 28–29
European corn borer, 18–20
Eurypterid, a new Eurypterid from the Devonian of New York, 88–92; preservation of alimentary canal in an, 92–95
Eusarcus newlini, 92

Fairchild, H. L., work of, 8; cited, 47, 48, 56
Ferns and flowering plants of New York State, 17
Forest insects, 24
Fossil plants, 9
Fossil trees of Schoharie county, 9–11

Gall insects, 24
Gall midges, 24
Geology, report on, 8; accessions, 32
Glossograptus quadrimucronatus, 63
Goldring, W., work of, 9
Gouverneur quadrangle, 8
Grain pests, 21–22
Graptolite zones of the Ordovician shale belt of New York, 116–30
Graptolites, homoeomorphic development, 63–68

Hartnagel, Chris A., work of, 8, 11
Horticultural inspection, 26

Indian Commission, activities, 14–15
Indian Welfare Society, 16
Iron ores, 8

Kemp, James F., work of, 8
Kokenospira rara nov., 106–7

Lake Bonaparte quadrangle, 8
Lake Champlain region, age of the black shales, 108–16
Lorraine beds, 123, 125
Lorraine fauna, investigations of, 8

Magog shale, 122–24
Miller, William J., work of, 8
Mineral industry, 8
Mineralogy, accessions, 37–38
Mollusca, living, 16
Mount Marcy quadrangle, 8

New York Indian Welfare Society, 16
New York State Archeological Association, 14
New York State Indian Commission, activities, 14–15
Newland, David H., work of, 8
Normanskill shale, 117–18

Oncoceras pupaeforme nov., 69
Onondaga limestone, 9
Orthoceras, color bands in, 79-88

Paleobotany, 9
Paleontologic contributions from the New York State Museum, 63–130
Paleontology, report on, 8; accessions, 32–37
Parker, Arthur C., Cornplanter medal bestowed on, 14
Potash, 8
Pterygotus inexpectans nov., 89, 90–92

Rice, Marion, work of, 8
Ruedemann, Rudolf, work of, 8, 11; Paleontologic contributions from the New York State Museum, 63–130
Russell quadrangle, 8

Salaries, inadequate, 7
Salt deposits, 8
Saratoga region, postglacial deposits and drainage, 8
Schaghticoke shale, 118–22
Schenectady beds, 123
Schizambon albaniensis nov., 105–6
Schoharie county, fossil trees, 9–11
Scientific papers, 39–130
Shade tree insects, 23
Shales, age of the black shales of the Lake Champlain region, 108–16; graptolite zones, 116–30
Snake Hill faunas, additions to, 101–8
Snake Hill shales, 123, 130
Staff of Department of Science, 29–31
Stevens, George E., work of, 13
Stoller, James H., work of, 8
Susquehanna valley, evolution of, 8

Tarr, R. S., cited, 47
Tetranota bidorsata, 106
Thompson, Mrs F. F., Boughton Hill site secured by favor of, 13; Cornplanter medal bestowed on, 14
Trematis punctostriata var. minor nov., 103–4
Trematis terminalis, 104
Trilobites, on some cases of reversion in, 70–79
Triplecia nucleus, 104–5
Tully glacial series, 39–62

Utica shale, 115, 124–26, 130

Vanuxem, L., cited, 46
Victor, archeological excavations on Boughton Hill, 11
Von Engeln, O. D., Tully glacial series, 39–62

West Point quadrangle, 8
Wild Flowers of New York, published, 16
Woodward, Herbert S., work of, 11

Zoology, report on, 26–28